WHAT ARE TUBENOSES?

In traditional classifications such as that of the American Ornithologists' Union (AOU) (1998), tubenoses are a well-defined group of seabirds that comprise the order Procellariiformes, and are so-named because their nostrils are encased in tube-like structures on the bill. Tubenoses are represented by up to five families worldwide: northern storm-petrels, southern storm-petrels, albatrosses, petrels (including shearwaters), and diving-petrels (a southern hemisphere family not covered in this guide, and sometimes merged with the petrels). Based upon DNA studies, Sibley and Monroe (1990) treated all of the tubenoses as a single family (Procellariidae) within the superfamily Procellarioidea, which also includes frigatebirds, penguins, and loons.

Tubenoses occur all over the world's oceans and vary in appearance from the tiny, swallow-like storm-petrels to the great albatrosses, among the largest of flying birds, with wingspans approaching 3.5 m (almost 12 feet)! Wings range from relatively broad and rounded in some storm-petrels to long, narrow, and pointed in the majority of species. Tails mostly range from squared to graduated, but several storm-petrels have forked tails. All tubenoses have 10 functional primaries and most have 12 rectrices (fulmars have 14, giant-petrels 16); the number of secondaries ranges from 11–13 in storm-petrels to 25–38 in albatrosses.

Bills vary from fairly short in storm-petrels to long and substantial in albatrosses, and all have hooked tips and are covered by distinct horny plates. The nostrils of albatrosses are mounted in small tubes on either side of the bill, whereas in petrels and storm-petrels they are fused into a tube on top of the bill base (Figs 1–2). Tubenoses drink saltwater and excrete

Fig 1. On albatrosses, such as this Black-footed Albatross, the nostril tubes lie on either side of the bill (cf. Fig 2). SNGH. Off Bodega Bay, California, 14 Aug 2007.

Fig 2. On petrels, such as this Sooty Shearwater, the nostrils open in a double-barreled tube at the base of the culmen (cf. Fig 1). SNGH. Off Monterey, California, 11 May 2008.

surplus salt in solutions that leak out of the nostril tubes. All species have short legs and webbed feet, with the hind toe absent (in albatrosses) to greatly reduced (in petrels and storm-petrels); the toes of burrowing species in particular have strong and sharp claws. Tubenoses have a well-developed olfactory bulb and use smell to find food and help locate their burrows in the dark (the plumage of most petrels and storm-petrels has a distinctive musky odor, which pervades their nests). It has even been found that adults of some species can distinguish by smell their own burrows from those of their neighbors (Bonadonna et al. 2003).

The plumage of tubenoses is dense and waterproof, hued in blacks, grays, browns, and whites. Some species are all-dark whereas others are strikingly patterned, with contrasting white uppertail coverts (as in some storm-petrels) or bold underwing markings (as in some petrels). The bills of most smaller species are black or dark, but some larger species, especially albatrosses, have brightly colored bills; the legs and feet of most species are blackish or pinkish overall.

Sexes appear alike in plumage although in some of the large albatrosses males more quickly develop "adult" plumage—a male Snowy [Wandering] Albatross 5 years old may be as white as a female 20 years old (Prince et al. 1997). In general, males average larger in albatrosses and petrels, whereas females average larger in storm-petrels. This is rarely apparent at sea except perhaps in bill depth or, with some albatrosses, in the bulk and width of the head (females having more slender heads). In most species the fledglings appear indistinguishable from adults, which is something to be thankful for in terms of at-sea identification. Appreciable age-related variation in appearance is largely limited to albatrosses. Molt in tubenoses is relatively poorly known. Most tubenoses do not molt their wings while breeding, and the time available for molt can be as little as a few months between successive breeding seasons. Thus, particularly among albatrosses, molt can involve novel strategies that allow the maximum number of primaries to be replaced in a short period. As adults, all tubenoses have one molt per cycle (a cycle for most species being a year), which, especially in larger species, is often incomplete, with not all remiges being replaced in a single cycle (see Molts, Plumages, and Aging, pp. 38–45). Because flight is so important to tubenoses, some species will skip a year of breeding to catch up on their molt rather than risk another season with impaired flight capabilities.

Except for the diving-petrels, which have sacrificed wing area to allow them to dive better (like northern hemisphere auks), tubenoses are generally accomplished fliers—as they have to be to live in such an open and windy environment (see Flight Manner, pp. 24–28). All rest on the sea surface, and many species dive well for food (especially shearwaters). Most tubenoses are migratory to some degree. These migrations vary from poorly understood shorter-distance dispersals to spectacular transequatorial odysseys.

Life at sea is all about finding food, which is patchy, mobile, and unpredictable (see Ocean Habitats, pp. 5–13). Tubenoses can survive fairly long periods without feeding and have a great ability to lay down subdermal fat for insulation, which helps them through fasting periods such as incubation (spells of which can last 3–4 weeks in albatrosses). Tubenoses find their food by sight and smell, and they forage by day and night (some food items perform vertical migrations, and only approach the surface at night); the main food groups are squid, fish, and crustaceans such as krill. Feeding strategies include scavenging, seizing prey near the surface, diving to depths of 50 m or more, and even pirating other species. Scavenging is a common form of feeding for many tubenoses, such as Tahiti Petrel and storm-petrels (Fig 3). This is why fish-oil slicks (which mimic dead fish) are successful in attracting certain tubenoses, notably petrels and storm-petrels, which can detect smells from miles away. Some fishing operations, mainly in productive temperate waters, provide large quantities of offal. Albatrosses and fulmars can gather in hundreds or even thousands to eagerly consume this "free food" (free in the myopic, human short term). In fact, the best way to find albatrosses in some areas is to locate active fishing boats. However, the practice of setting baited hooks (such as the thousands used by

Fig 3. Many species of tubenoses, here a Black-capped Petrel and a Wilson's Storm-Petrel, scavenge dead squid and fish, which can be detected from miles away courtesy of an acute sense of smell. SNGH. Off Hatteras, North Carolina, 15 Aug 2009.

Fig 4. Pink-footed Shearwaters over Humpback Whale. Several species of petrels feed in association with whales and dolphins, presumably scavenging spillage and scraps. SNGH. Off Monterey, California, 26 Sep 2008.

long-line fishing operations) without protecting them from hungry tubenoses causes countless birds to take the bait and drown—a major source of mortality for some species, particularly albatrosses, and a serious conservation issue that is beginning to be addressed.

In tropical waters, schools of dolphin and tuna chase schools of fish to the surface, allowing many tubenoses to feed on the smaller fish being pursued as well as on left-over scraps. For example, Juan Fernandez Petrels and Wedge-tailed Shearwaters (along with Sooty Terns and numerous other species) feed over yellowfin tuna in the tropical Pacific Ocean (Spear et al. 2007), Parkinson's Petrels often scavenge in association with dolphins off Middle America (Pitman & Ballance 1992), and Pink-footed Shearwaters often forage over whales or schools of dolphins off California (pers. obs.; Fig 4).

Fig 5. Hybrid Laysan x Black-footed Albatross with plumage pattern superficially suggesting Galapagos Albatross. RdG. Midway Atoll, Hawaii, 28 Dec 2006.

All tubenoses nest on or under ground, typically on islands that are (or were) free from predators, and most species are colonial. Long-distance migrants and species breeding at high latitudes tend to be more synchronized in their breeding, whereas tropical species and shorter-distance migrants tend to have more protracted and less synchronized cycles. A high degree of philopatry characterizes tubenoses, and young birds generally return to their natal islands for breeding; when breeding islands are at carrying capacity, however, young birds may range widely in search of suitable new breeding sites. Larger species such as albatrosses and fulmars are diurnal at the breeding grounds and nest on the surface, whereas most smaller species are nocturnal and nest in burrows or crevices, coming and going at night to avoid predators such as hawks, falcons, gulls, and skuas.

The ocean is not a gentle or forgiving mother, and tubenoses need to know what they're doing before they start breeding. All species have a conservative reproductive strategy characterized by late maturity, low reproductive rates, and long life spans. The typical age of first breeding in tubenoses ranges from 4–5 years in storm-petrels to 6–13 years in albatrosses, some of which can live for 50 or more years. Prebreeding birds visit colonies for a few years before settling, and arrive earlier each year as they get older to develop long-lasting monogamous pair bonds. Breeders usually return at least one or two months before egg-laying, to bond with their mates and refurbish the nest site. A prelaying exodus, or "honeymoon" period, when birds leave the nesting grounds for 2–4 weeks, is characteristic of tubenoses and most apparent in species with synchronized breeding systems. During this time the egg is developed and birds store food reserves for incubation spells. Incubation for the single white egg ranges from about 6–8 weeks in storm-petrels to 9–11 weeks in albatrosses. Fledging requires from around 7–10 weeks in storm petrels to 20–40 weeks in albatrosses, and nestlings are adapted to survive weeks without food while their parents roam the oceans. In the largest albatrosses, more than a year is required for a breeding cycle and so these birds only breed every other year. Hybrid tubenoses—derived from two species interbreeding—appear to be very rare, and the only well-documented ones that occur in the region are those between Black-footed and Laysan albatrosses (Fig 5). Even so, these are sufficiently rare that most birders will never see one.

The voices of tubenoses are unmusical and heard mostly at or near the breeding grounds. They comprise a variety of brays, whinnies, purring chatters, whistles, moans, and sometimes other-worldly shrieks and screams. Periods of loud calling over storm-petrel colonies in the middle of the season, after laying or hatching, may be due largely to the presence of prebreeding immatures. Calls, in conjunction with ritualized display postures and bouts of bill-clapping in some species, serve important social functions during courtship, territorial disputes, and arguments over food. Calls are of limited value for identification except at night on the breeding grounds when, e.g., they enable different species of storm-petrels to be distinguished. An excellent reference to the sounds of tubenoses in the Northeast Atlantic is the Sound Approach guide by Magnus Robb and colleagues (Robb et al. 2008).

OCEAN HABITATS

As with all birds, habitat is a key to understanding patterns of distribution and occurrence. We all readily recognize grasslands, marshes, conifer forests, and such on land, but what of marine habitats? The oceans are not simply wet and salty but instead they comprise many habitats usually invisible to the human eye (Figs 6–7). On land, these habitats would be as different as deserts are from rainforests, and at sea they are *mobile* deserts and rainforests! Both large-scale and small-scale physical processes in the ocean can change the habitat in an area overnight, as many people who have taken pelagic trips on two consecutive days to the same area can attest. We are a long way from understanding, let alone predicting, many of the large-scale, let alone small-scale, changes to which seabirds respond. The following is a simplified overview of the oceans as they relate to habitat for seabirds, particularly tubenoses.

Figs 6–7. Like many wide-ranging tubenoses, Great Shearwaters encounter varied sea conditions in their annual cycle, from mountainous southern seas near the breeding islands (sea-surface temperature 10°C) to the Gulf Stream in glassy calm (sea-surface temperature 27°C). Note the retained juvenile outermost primary cutting the water, identifying a second-cycle bird. SNGH. South Atlantic (45°S, 21°W), 6 Apr 2009, and off Hatteras, North Carolina, 26 May 2008.

Current Systems (Fig 8a–8b)

Oceans and seas are the contiguous saltwater masses that cover about 70% of the Earth's surface. They surround and define land masses and are dynamic water bodies within which patterns of predictable circulation can be identified at different depths. Ocean currents are the dominant feature of surface movement and they broadly correspond to the direction of prevailing winds, which themselves are a consequence of the easterly direction of the Earth's rotation, solar heating, and the torque of the Coriolis force.

This means that at the large scale of ocean basins the prevailing winds (and currents) are easterly (flowing from east to west) in tropical latitudes, westerly in mid-temperate latitudes, and easterly again at high latitudes. Conversely, the continental coasts have an overall north-south orientation. Thus, in the Americas, westward-flowing equatorial currents driven by the easterly Trade Winds push water away from Pacific coasts but toward Atlantic coasts, whereas eastward-flowing mid-latitude currents driven by prevailing westerly winds push water toward Pacific coasts and away from Atlantic coasts.

The Coriolis force lends a clockwise direction to mid-latitude water mass circulations in the northern hemisphere and a counterclockwise direction in the southern hemisphere. Consequently, in low to mid-latitudes there is a flow of relatively cold, higher-latitude water toward the equator along the eastern edges of the oceans, forming eastern boundary currents such as the California Current and Humboldt (or Peru) Current. Conversely, relatively warm tropical water flows away from the equator along the western edges of the oceans, forming western boundary currents such as the Gulf Stream and Kuroshio Current. At high latitudes, the current patterns reverse with the reversal of prevailing winds, and relatively warm water flows north into the Gulf of Alaska as the Alaska Current, while cold water flows south from the Davis Strait as the Labrador Current. To maintain equilibrium (all of the westward-flowing tropical water has to be replaced somehow), roughly along the equator there is an eastward-flowing current (the Equatorial Counter Current) that transports water back across the oceans between the North Equatorial and South Equatorial currents.

In addition to these major current systems there are numerous smaller-scale currents. In the Pacific, e.g., on reaching the American mainland the Equatorial Counter Current splits into the relatively warm, and usually weak, north-flowing Costa Rica Current and the south-flowing, somewhat submerged Peru Undercurrent. In the North Pacific, the Alaska Current curves around to form a westward-flowing current along the south side of the Aleutians, but some water splits off to enter the eastern Bering Sea (through Unimak Pass) and circulate in a clockwise gyre over the continental shelf.

The inherently dynamic nature of ocean water masses means that currents vary in their strength and position (even on a daily basis), but the broad patterns are consistent and helpful to have in mind when considering seabird distribution.

Thermoclines, Upwelling, and Fronts

The oceans are not uniform in nature, and within them we can distinguish distinct water masses by characteristics such as their density, which is a product of temperature and salinity. Temperature is the feature most easily appreciated by humans, although salinity may be more important in defining habitats for marine organisms. The bottom line is that the interactions of different water masses affect biological productivity. When organisms in the sea die they sink, taking the nutrients needed for photosynthesis into the cooler, deeper ocean waters. But photosynthesis can occur only in surface waters to the depth of sunlight penetration. Thus biological productivity depends in part on forces that bring nutrient-rich cooler waters into the zone where photosynthesis can occur.

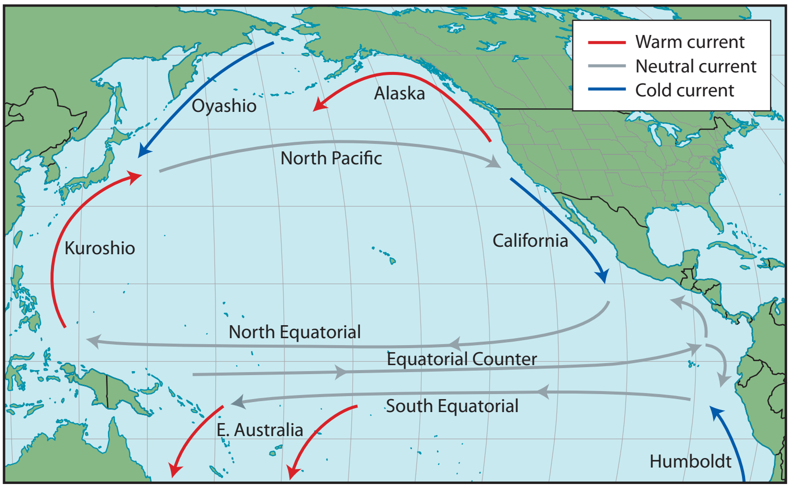

Fig 8a–8b. An overview of ocean currents relating to North American waters (warm, neutral, and cold are relative terms for the prevailing currents). At mid-latitudes, warm currents such as the Gulf Stream flow away from the equator along eastern coasts, whereas cold currents, such as the California Current, flow toward the equator along western coasts.

Thermoclines. Productivity can often be inferred by looking at the nature of the temperature gradient between warmer surface waters and cooler subsurface waters, which is called a thermocline. This gradient may be abrupt (a strong thermocline) or diffuse (a weak thermocline), and it can be nearer to (shallow) or farther from (deep) the sea surface.

For example, strong, deep thermoclines indicate little mixing of the cooler, nutrient-rich subsurface waters with the warmer, nutrient-poor surface waters. Ocean areas with these characteristics tend to be biologically unproductive, like the vast areas of “blue water” in the tropical and subtropical Central Atlantic and Central Pacific oceans, which are effectively marine deserts. Some species, such as Bulwer’s Petrel, seem adapted to roam these deserts in search of food, but in general such areas are poor in seabird life. The much-publicized El Niño events that cause periodic food-web crashes in the Humboldt and California currents occur when the thermocline deepens; this happens when the Trade Winds slacken, which allows warm surface water that has been pushed to the western Pacific to slop back to the east and intrude over cooler water masses.

Weak and shallow thermoclines, on the other hand, indicate mixing of water masses, so that nutrients and sunlight combine. Hence there is increased food productivity, which extends through the food web to seabirds. Such mixing occurs where cool subsurface waters are drawn toward the surface (or upwelled) and where different water masses meet (at fronts).

Upwelling can occur in a number of ways. For example, where surface waters have a tendency to diverge, the “space” thus created may be filled by upwelling of cooler subsurface waters. Waters along the equator are relatively cool for this reason, because the Trade Winds driven by the Coriolis force tend to push the surface water north and south away from the equator. Upwelling also occurs when subsurface currents hit rises in the seafloor and are forced upward, so that nutrient-rich waters may be pushed into the sunlight zone, e.g., over seamounts, submarine canyon walls, and the continental shelf break. Tidally induced currents can also contribute significantly to upwelling among islands and over continental shelf waters, such as at Georges Bank, between Cape Cod and Nova Scotia, and in Hecate Strait, inshore of the Queen Charlotte Islands off British Columbia, where large numbers of Sooty Shearwaters gather to molt (Fig 9).

The best-known types of upwelling are the wind-driven systems associated with eastern boundary currents such as the California and Humboldt currents, which are rich feeding grounds for seabirds. But even in these areas productivity is cyclic because wind direction and strength vary, often on a seasonal basis. Upwelling can be greatly suppressed if the prevailing winds simply aren’t blowing, but then even a day or two of strong winds can generate significant upwelling.

The frictional drag of wind on the ocean surface, combined with the Coriolis force, means that water flows at an angle to the wind direction: water angles to the right in the northern hemisphere, to the left in the southern hemisphere. Thus, in spring and summer (mainly March to August) the prevailing northwest winds along the Pacific coast from Oregon to California cause surface water to flow to the “right,” or offshore, and cool subsurface water upwells at the coast to take its place before being similarly conveyed offshore. Two other areas of seasonal Pacific coastal upwelling in North America are around the Gulf of Tehuantepec, in southern Mexico (mainly October to March), and in the Gulf of Panama (mainly January to April), where strong winds funnel across the land isthmuses from the Gulf of Mexico and Caribbean; large numbers of Black and Least storm-petrels occur in both areas at these seasons. During El Niño events the deepened thermocline means that warm, nutrient-depleted water upwells instead of cold water, and marine productivity is greatly reduced even with upwelling.

Fronts represent the meeting of different water masses. They are three-dimensional systems, and the depth to which they extend in the water column varies with their scale and with local conditions. They can be large scale, as between the Labrador Current and Gulf Stream

Fig 9. Sooty Shearwaters gather locally in swarming masses off the West Coast to feed in food-rich waters that fuel their wing molt. SNGH. Monterey Bay, California, 24 Jul 2008.

Fig 10. Few ocean fronts are as abrupt as the break between the cold green Labrador Current (at back, around 5°C) and the warm blue Gulf Stream (in front, around 16°C and warming rapidly away from the front). Food items, and thus birds (such as these Dovekies *Alle alle*), often concentrate along such fronts. SNGH. Off Hatteras, North Carolina, 14 Feb 2010.

(Fig 10), or small scale, such as the passes between some Aleutian Islands where North Pacific and Bering Sea water masses are mixed by tidal-current action that also promotes local upwelling; many Short-tailed Shearwaters gather to molt in these productive areas.

The relatively shallow waters over the continental shelf usually differ from deeper offshore waters in temperature and salinity (e.g., shelf waters are fed by freshwater runoff from land and are mixed more by tidal action); these water masses meet and mix at what are known as shelf-break fronts, areas of generally high productivity. Upwelling fronts occur when cool, *Fig 11.* Sargassum weed and associated tubenose prey items concentrate at fronts between different water masses along the edges of the Gulf Stream. SNGH. Off Hatteras, North Carolina, 26 May 2007.

upwelled water flowing offshore sinks where it meets warmer, less dense water; plankton are usually concentrated at upwelling fronts, which are often good for birds. The shelf-break front and upwelling fronts often lie over the continental shelf break, where current-driven upwelling can further enhance productivity—so it is not surprising that the shelf break is usually a good area for seabirds and seabirding.

Other, usually short-lived, fronts are the locally wind-driven or tidally driven convergences marked by strips of glassy, slick-like water dotted with lines of debris and weed (Fig 11), among which are fish eggs, gelatinous zooplankton, and other biological matter. Off California in fall these small-scale fronts often attract Buller's and other shearwaters, phalaropes, Long-tailed Jaegers, and Xantus' Murrelets. Off the southeastern U.S. in summer they are good areas to find Audubon's and other shearwaters, and Bridled and other terns. Internal waves (subsurface waves that generate vertical undulations in the thermocline) are another physical phenomenon that helps explain the small-scale patchiness of seabirds within larger-scale water masses, as noted for Black-capped Petrels off the southeastern U.S. (Haney 1987a).

Habitat Associations

For tubenoses, at-sea habitat translates largely to food. But food in the oceans is not evenly spread, and it is also dynamic in its distribution: trying to predict details of tubenose distribution patterns at sea is a little like trying to predict exactly when and where it will rain. Still, as with climatic zones on land, broad-scale marine habitat zones can be identified. Characteristics of marine habitats are rather different from those we associate with habitats on land, and include sea-surface temperature and salinity, thermocline depth and strength, ocean depth (such as over or offshore of the continental shelf), and even wind strength and wind direction. For example, albatrosses need sufficient wind speeds to support their flight, and they avoid areas with persistently low winds or calm conditions.

Within broader-scale habitats there are hotspots that concentrate food and are favored by seabirds, and by birders. For example, in the Cordell Bank National Marine Sanctuary, off the central California coast, the outer boundary of the wind-driven upwelling system corresponds with the shelf-break front and is enhanced by tidally induced and subsurface current upwellings; this all results in a productive area where 25 species of tubenoses, including 5 albatrosses, have been recorded.

As with terrestrial habitats, the avifaunas of marine habitats vary seasonally. The California Current system is a well-studied example. In spring and summer, persistent northwest winds from Oregon to central California drive the upwelling of cool, nutrient-rich, south-flowing waters that support a large avifauna of locally breeding and migrant seabirds. With changing atmospheric conditions in fall, the northwest winds decrease in both strength and persistence, the upwelling productivity is reduced, and warmer oceanic water moves onshore (mainly during August to October, when several warmer-water seabirds expand their ranges northward). The winter climate that follows is characterized by southerly winds, which allow the relatively warm, northward-flowing, and usually subsurface Davidson Current to dominate inshore marine waters during November to March (when productivity is reduced and fewer tubenoses occur), before the northwest winds return in spring.

Different habitats show varying degrees of overlap. In the Pacific Ocean, Wahl et al. (1989) found that the high-temperature/high-salinity avifauna of the subtropical North Pacific overlapped little with the three colder water/lower-salinity avifaunas to the north and east, which had numerous species in common. Habitats can also be interpreted differently. For example, Gould and Piatt (1993) recognized 3 avifaunas (comprising 14 species guilds) within the 2 offshore North Pacific avifaunas identified by Wahl et al. (1989). Tables 3–4 list the broad-scale distribution of tubenose avifaunas in North American waters during spring to fall.

Table 3. Simplified overview of Pacific Ocean habitat associations for regularly occurring petrels, albatrosses, and storm-petrels in North American waters from spring through fall (roughly Apr–Oct). BERS: Bering Sea region; NOPA: North Pacific (e to se Alaska); INCC: Inshore California Current (coastal upwelling zone out to shelf break, n to Vancouver Island); OFCC: Offshore California Current (seaward of the main upwelling and shelf break); INTP: Inshore Tropical Pacific (inshore waters out to the shelf break); OFTP: Offshore Tropical Pacific (offshore from the shelf break). ^{G}Also in Gulf of California; ^{S}Southern section (s of cen California); ^{N}Northern section (n of cen California). X: primary habitat associations and commoner species; x: smaller numbers occur or species generally uncommon to rare.

	BERS	NOPA	INCC	OFCC	INTP	OFTP
Sooty Shearwater		X	X^{G}	x		
Short-tailed Shearwater	X	X	x			
Flesh-footed Shearwater		x	x	x		
Pink-footed Shearwater		x	X^{G}	X		
Buller's Shearwater		x	X	X		
Wedge-tailed Shearwater					X	X
Manx Shearwater		x	x			
Townsend's Shearwater					X	x
Black-vented Shearwater			X^{S,G}		X	
Galapagos Shearwater					X	
Christmas Shearwater					X	x
Cook's Petrel		x		X		
Mottled Petrel	X	X				
Hawaiian Petrel				X		
Galapagos Petrel						X
Juan Fernandez Petrel						X
Murphy's Petrel		x		X		
Kermadec Petrel						X

Table 3.*cont.* Simplified overview of Pacific Ocean habitat

	BERS	NOPA	INCC	OFCC	INTP	OFTP
Herald/Henderson Petrel						x -
Tahiti Petrel						X -
Northern Fulmar	X	X	x	X -		
Parkinson's Petrel						X -
Black-footed Albatross	x	X	X	X		
Laysan Albatross	X	X	x	X -		
Steller's Albatross	X	x	x	x -		
Wilson's Storm-Petrel			x -			
Leach's Storm-Petrel		X		X		X
Wedge-rumped Storm-Petrel					X -	X
Black Storm-Petrel			X^S,G		X	
Least Storm-Petrel			X^S,G		X	
Ashy Storm-Petrel			X	x -		
Markham's Storm-Petrel						X -
Fork-tailed Storm-Petrel	X	X	X^N	X^N		
	BERS	NOPA	INCC	OFCC	INTP	OFTP

Table 4. Simplified overview of Atlantic Ocean habitat associations for regularly occurring petrels, albatrosses, and storm-petrels in North American waters from spring through fall (roughly Apr–Oct). LABC: Labrador Current (cooler waters); GULS: Gulf Stream (warmer waters). ^G Also in Gulf of Mexico; ^C Also in Caribbean. X: primary habitat associations and commoner species; x: smaller numbers occur or species generally uncommon to rare.

	LABC	GULS
Sooty Shearwater	X	x -
Great Shearwater	X	x -
Cory's Shearwater		X^G,C
Audubon's Shearwater		X^G,C
Manx Shearwater	X	x
Black-capped Petrel		X^C
Bermuda Petrel		x
Cape Verde/Desertas Petrel		x
Trinidade Petrel		x
Northern Fulmar	X -	

Table 4. ***cont.*** Simplified overview of Atlantic Ocean habitat

	LABC	**GULS**
Wilson's Storm-Petrel	X	X
Leach's Storm-Petrel	X	x
Grant's [Band-rumped] Storm-Petrel		X[G]
White-faced Storm-Petrel		x
	LABC	**GULS**

PHYLOGENY, BIOGEOGRAPHY, AND VAGRANCY

The habitats described above help explain seabird distributions as we see them today. But environments are nothing if not dynamic, and a longer-term view of tubenose distributions is also of interest in understanding present-day patterns and perhaps in predicting future trends. The origins of tubenoses are shrouded in the mists of prehistoric time, but different lines of evidence agree on a common ancestor for penguins, tubenoses, and loons (Cracraft 1981, Olson 1985, Sibley & Alquist 1990). The fossil record also indicates that the tubenose families recognized today were distinct some 30 million years ago, and that most modern genera existed around 10 million years ago (Brooke 2004).

The times and rates of evolution for different groups of tubenoses are contentious, but the order likely originated in the southern hemisphere along the shores of a fragmenting Gondwanaland. It appears that storm-petrels split first from the ancestral tubenose lineage, followed by the albatrosses, and then the ancestor of petrels and diving-petrels, with the diving-petrels having diverged relatively recently (Harper 1978, Nunn & Stanley 1998; Fig 12).

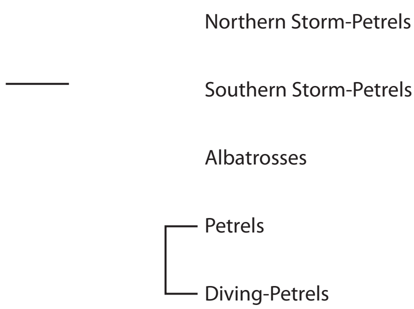

Fig 12. Relationships among present-day tubenose families (from Nunn & Stanley 1998); the earliest branching was northern storm-petrels, followed by southern storm-petrels and albatrosses.

Until much more work is undertaken, unraveling the geographic origins of different families and genera of tubenoses will remain controversial. Islands and shores of the proto-Pacific Ocean seem likely candidates, however, given that the Indian Ocean and Atlantic Ocean did not open up until the plates of Gondwanaland diverged. Certainly, the modern-day breeding distributions of tubenoses are heavily weighted to the Pacific and to the southern hemisphere. Tubenoses, however, are tied to oceanic habitats, not to land, and their present-day breeding distributions may simply reflect the nearest predator-free land masses as much as any biogeographic ties to the immediately surrounding seas.

Tubenose distributions are ever-changing over different time scales, and what we see today are relics of a richer, more diverse bygone era. For example, the fossil record indicates that around 2–4 million years ago up to five species of albatrosses roamed the North Atlantic, where none is regular today, and there was even a breeding population of Steller's Albatrosses on Bermuda! (Olson & Rasmussen 2001). Even in our lifetimes we can see changes. For example, Northern Fulmars and Manx Shearwaters spread across the North Atlantic from western Europe to North America in the 1960s and 1970s and, as I write this, Manx Shearwaters appear to be colonizing the North Pacific. Laysan Albatrosses have colonized islands off west Mexico since the 1980s, apparently because their Hawaiian nesting grounds reached carrying capacity so that young were forced to roam in search of new lands. Given the strong philopatry of breeding adult tubenoses, the pioneering movements of young birds have likely resulted in range shifts and expansions. New colonizations need not always be driven by increasing populations: steadily rising sea levels during past eras would have reduced the area of nesting grounds and caused a steady shift in breeding distributions (or extinctions, if no alternative breeding sites could be found). Something similar may be happening today on islands where burgeoning fur seal populations appear to be limiting albatross nesting sites (such as of Snowy [Wandering] Albatross on South Georgia, and of Salvin's Albatross on the Bounty Islands).

The occurrences of vagrant tubenoses visiting islands beyond their breeding range are noteworthy events in the birding world, but might some be precursors of range changes that will span thousands of years? Could they be inexorable responses to climatic change? Or are they simply random events? Examples include Black-browed Albatross and Barolo Shearwater in Britain, Wedge-rumped Storm-Petrel and Cory's Shearwater off Baja California, Mexico, Salvin's Albatross in Hawaii, Trinidade Petrel in the West Indies, and Bermuda Petrel in the Azores.

Of the 70 or so tubenose species recorded in North America, only 16 breed in the region covered in this guide; about 36 are regular or probably regular nonbreeding visitors (some occurring in only very small numbers) from breeding grounds as distant as Hawaii, Japan, Australia, New Zealand, Chile, Antarctica, Europe, and the South Atlantic; and about 17 appear to be vagrants. Most vagrants originate from habitats similar to those found in the region: 12 species (9 albatrosses, 2 petrels, 1 storm-petrel) come from temperate and subtropical latitudes of the southern hemisphere, whereas only 5 species (1 albatross, 2 petrels, 2 storm-petrels) come from tropical regions and subtropical northern latitudes adjacent to the region. Thus, in temperate waters off California you are more "likely" to encounter species of temperate southern hemisphere waters (such as Gray-faced [Great-winged] Petrel) than to find species that occur much closer but over tropical and subtropical waters (such as Kermadec Petrel).

TAXONOMY AND AN IDENTIFICATION FRAMEWORK

Taxonomy is the science of classification and it allows us to place birds within a frame of reference. Birds, like all living organisms, are classified by a hierarchal system. The category most familiar to birders is that of a *species*, and an important category just above the species level is the *genus*; a subgenus is a grouping between the levels of genus and species. Each genus (and subgenus) has certain shared characteristics, an appreciation of which can be helpful in identification. For example, Leach's Storm-Petrel, like other members of the genus *Oceanodroma*, has relatively narrow and angled wings with a long arm, whereas Wilson's Storm-Petrel, like other members of the genus *Oceanites*, has relatively broad-based and straight wings with a short arm.

Each described organism on Earth has a scientific name, which is italicized and comprises its genus name (capitalized) and species name (lowercase). Variation within a species, if noticeable and correlated with geographic populations, may be expressed by means of *subspecies* (also called races); species with recognized subspecies are termed *polytypic*. A species is *monotypic* if no subspecies are recognized. A subspecies name is the third and last part (also termed an epithet, or trinomial) of the scientific name. With few exceptions, the first-described population retains the same subspecies epithet as the species epithet, and is known as the nominate subspecies. For example, the nominate subspecies of Northern Fulmar is *Fulmarus glacialis glacialis* (often abbreviated to *Fulmarus g. glacialis*), which breeds in the North Atlantic, while the subspecies *Fulmarus glacialis rodgersii* breeds in the North Pacific and can be classified as:

Class: Aves
Order: Procellariiformes
Family: Procellariidae
Genus: *Fulmarus*
Species: *glacialis*
Subspecies: *rodgersii*

The classification of tubenoses has followed a long and tortuous path, with much debate about whether separate populations are species or subspecies. Many taxa, populations, or even color morphs were originally described as separate species. A conservative period followed, with some rather extreme lumping based largely on philosophical grounds rather than new data. Thus, e.g., Murphy (1952) subsumed eight taxa of shearwaters as one, the Manx Shearwater (all eight are now considered full species again).

Like all traditional classifications, that of tubenoses has relied heavily on plumage patterns and external morphology. Recent genetic studies have repeatedly shown, however, that some taxa may diverge yet show little external evidence of their genetic separation, whereas distantly related taxa can converge in appearance and morphology. An example of the former situation occurs with different populations of Band-rumped Storm-Petrel, which may comprise as many as 10 species worldwide, with 4 in the northeastern Atlantic alone (Robb et al. 2008). An excellent example of the latter situation is the Little Shearwater/Audubon's Shearwater complex, which traditionally has been considered to comprise two widespread but rather variable species: the higher-latitude Little Shearwater, with a shorter tail and white undertail coverts, and the lower-latitude Audubon's Shearwater, with a longer tail and dark undertail coverts. Austin et al. (2004) showed that this complex comprises multiple species, and that one population of "Little" Shearwater from the North Atlantic is actually an "Audubon's" Shearwater! An interesting parallel in morphological variation occurs in the Manx Shearwater complex, such as between the higher-latitude Manx (with a shorter tail and white undertail coverts) and the lower-latitude Townsend's Shearwater (with a longer tail and dark undertail coverts).

As well as finding that traditional morphology does not necessarily reflect relationships, genetic studies have revealed a trend for geographic clades, whereby a presumed ancestor colonized an area and then diversified. Examples include the North Pacific clade of *Phoebastria* albatrosses, and the North Atlantic clade comprising Audubon's, Boyd's, and Barolo shearwaters, with the last-named resembling the southern hemisphere Little Shearwater complex (Austin et al. 2004). A further complication is that specimens may look similar in a museum tray whereas the birds in life (and genetically) are quite different. An example is the Fea's Petrel complex, which is part of a North Atlantic clade (including Black-capped and Bermuda petrels) and not closely related to the southern hemisphere Soft-plumaged Petrel (Nunn & Stanley 1998), with which Fea's was lumped for many years based on superficial similarities.

As new information becomes available, subspecies are being elevated to species rank (such as Hawaiian and Galapagos petrels; AOU 2002), cryptic species are being identified (such as Henderson Petrel; Brooke & Rowe 1996), and some distinct taxa even remain to be named (such as Grant's [Band-rumped] Storm-Petrel). Thus, taxonomy within the tubenoses remains dynamic—and often controversial, such as proposals to elevate all albatross taxa to the level of species. In birds as site-faithful as albatrosses every island population could, in theory, evolve into a species: witness the coexistence of Desertas [Fea's] and Zino's petrels in the Madeira archipelago, and the differences found among populations of Galapagos Petrels from different islands in the Galapagos archipelago (Tomkins & Milne 1991). The difficulty, for humans, lies in determining how differentiated insular populations have become—which should be recognized as species and which should not?

Despite the state of flux in tubenose taxonomy and nomenclature, the classification of the American Ornithologists' Union *Checklist of North American Birds* (and subsequent supplements) is particularly anachronistic and is not followed here. Instead, I have tried to pick a realistic course through various taxonomic papers (Austin 1996, Austin et al. 2004, Chambers et al. 2009, Harper 1978, Imber 1985, Nunn & Stanley 1998, Viot et al. 1993), but I acknowledge the fluid state of tubenose taxonomy. One recent review of taxonomy and nomenclature in tubenoses as a whole (Penhallurick & Wink 2004) contained numerous flaws (Rheindt & Austin 2005) and has not been generally accepted. Another review (Kennedy & Page 2002) represented an exercise in statistics more than an advance in taxonomy.

Tubenoses have been traditionally divided into four families: albatrosses, petrels, diving-petrels, and storm-petrels (Figs 13–15). Recent studies, however, suggest it is more realistic to treat diving-petrels as a subfamily within petrels, and to consider storm-petrels as two families (see Fig 12). Some features of each genus or subgenus within these families are described below (at least for species recorded in North America). In the species accounts these families and genera are subdivided into groups convenient for field identification, which do not necessarily reflect taxonomic relationships.

Fig 13. Black-footed Albatross and Chapman's [Leach's] Storm-Petrel are examples of the larger and smaller tubenoses; both scavenge together at squid and fish carcasses. SNGH. Off San Diego, California, 25 Aug 2009.

Fig 14. Although large for a petrel, this Pink-footed Shearwater is dwarfed by a Black-footed Albatross (an adult with extensively white uppertail coverts), which is relatively small for an albatross. SNGH. Off Monterey, California, 21 Sep 2007.

Fig 15. The small size of Wilson's Storm-Petrel is readily appreciated with a Cory's Shearwater for scale. SNGH. Off Hatteras, North Carolina, 31 May 2007.

Family Procellariidae: Petrels

Petrels, which include shearwaters, are a well-defined family of tubenoses, but over the years they have been divided into many different groups by different authors. There is increasing agreement that both the fulmar clade (represented in the northern hemisphere by one species, with six other species in five genera inhabiting the cold Southern Ocean) and the *Pterodroma* clade are distinct monophyletic groups. Other relationships are less clear, including those of the shearwaters and the genera *Procellaria*, *Bulweria*, and *Pseudobulweria* (as well as of some southern hemisphere genera unrecorded in North America). Genetic studies confirm that the traditional *Puffinus* shearwaters are not monophyletic (Austin 1996, Nunn & Stanley 1998). Thus the larger "*Puffinus*" shearwaters are treated here in the genus *Ardenna,* with *Puffinus* reserved for the smaller shearwaters, which share a common ancestor with *Calonectris*. Fig 16 shows a provisional phylogeny of present-day petrel genera recorded in North America. The following genera occur in North American waters, listed here in the sequence of three main groups used for identification (shearwaters, gadfly petrels, and other petrels).

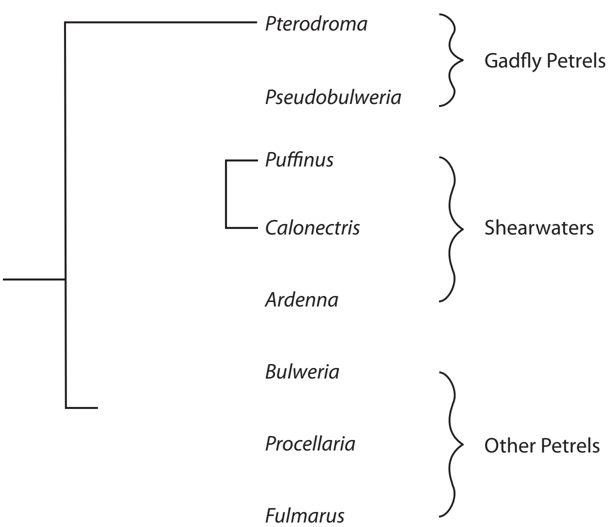

Fig 16. Provisional relationships among present-day petrel genera recorded in North America (from Bretagnolle et al. 1998, Nunn & Stanley 1998).

Shearwaters comprise three genera worldwide, all found in the region: *Ardenna*, *Calonectris*, and *Puffinus*. Gadfly petrels in the region comprise two genera: *Pterodroma* and *Pseudobulweria*. Other petrels in the region involve three genera: *Fulmarus*, *Procellaria*, and *Bulweria*.

Genus *Ardenna*. Seven species of large shearwaters, all of which occur in the region; six breed in the southern hemisphere and migrate to the northern hemisphere to molt, and one (Wedge-tailed) breeds and ranges in the tropics. This genus might best be considered as multiple genera, but it is recognized here provisionally to highlight that these large shearwaters are not closely related to true *Puffinus*. Bills are relatively slender, varying from blackish to pink with a black tip, and legs and feet are pink to dusky overall. Plumage is all-dark or bicolored. Wedge-tailed and Buller's are a distinctive pair that can be recognized in the subgenus *Thyellodroma*, differing from other species in lighter build, relatively broader wings, and longer, strongly graduated tails, which combine to give them a buoyant flight manner befitting their lower-latitude distribution. Typical *Ardenna* are heavier bodied with shorter tails and narrower and stiffer wings, and inhabit higher latitudes with stronger winds. For species identification note flight manner, overall plumage pattern, tail shape, head and neck patterns, bill color and size, and underwing pattern.

Genus *Calonectris*. Four species (all recorded in the region) of large shearwaters with long and overall pale bills, broad wings, and medium-long graduated tails. All breed in warm subtropical waters of the northern hemisphere and further differ from *Ardenna* in having longer and heavier bills, rounded tarsi, lighter skeletons, and more marked sexual dimorphism (male bills being 5–13% longer than those of females). For species identification check head and neck pattern, bill color, and underwing pattern.

Genus *Puffinus*. At least 26 species (taxonomy is vexed) of small to very small shearwaters. That only eight species have been recorded in the region reflects the relatively sedentary habits of many taxa. *Puffinus* shearwaters are widespread in tropical and mid-latitudes. Most species are bicolored, dark above and white below, although two are dark overall, including Christmas Shearwater, which traditionally has been associated with the larger shearwaters. Bills are dark overall, and legs and feet mostly pinkish to pale bluish. Similarities in plumage patterns have clouded the determination of species limits, and it is likely that more species await recognition, or even formal discovery. For species identification note overall structure (especially tail length), head and neck pattern, undertail-covert pattern, underwing pattern, and bill size.

Genus *Pterodroma*. Approximately 30 species (taxonomy is vexed) widespread in tropical and subtropical latitudes. They are often simply called pterodromas in birding talk, or known as gadfly petrels because of their impetuous flight manner. In North American waters at least 15 species of gadfly petrels have been recorded. Gadflies are small to medium-sized petrels that range from all-dark to bicolored, with dark upperparts and white underparts; the upperparts of several species have a blacker M pattern. The bills are black, notably stout on larger species but relatively slender on some of the smaller species; the wings are generally long, relatively narrow, and pointed, characteristically held pressed slightly forward, crooked at the carpals, and flexed; the tails are slightly to distinctly graduated, varying from medium-short and relatively squared to medium-long and tapered; the toes do not project in flight and usually the feet are hidden in the plush undertail coverts; legs and feet vary from all-dark to pale pinkish or pale bluish with black distal toes and webbing. The genus may include multiple genera, but data are not available to resolve relationships for all species. For species identification note overall size (small, medium, or large), head and neck pattern, underwing pattern, flight manner, and bill size.

Genus *Pseudobulweria*. Four or more poorly known tropical species of medium-sized petrels with very stout black bills, long wings, and medium-long graduated tails. One distinctive species (Tahiti Petrel) occurs in the region and has very long narrow wings and overall dark plumage with a contrasting white belly and undertail coverts.

Genus *Fulmarus*. These are two species (one in the region) of fairly large petrels with stout pale bills, fairly broad and stiffly held wings, and medium-short, slightly graduated tails. Fulmars inhabit cold temperate waters, often scavenge at fishing boats, and are readily identifiable.

Genus *Procellaria*. Five species of fairly large petrels that breed in the southern hemisphere, four of which (including the two species recorded in North America) have predominantly blackish plumage and blackish legs and feet, and are sometimes called "black petrels." *Procellaria* bills are pale yellowish overall with well-defined plates and tend to be slightly stouter than shearwater bills; their wings are long and fairly broad, and the tails medium-short and graduated (the toes can project in flight). For species identification note bill size and pattern, overall size (relative to other species), and any white markings on the chin or head.

Genus *Bulweria*. Two distinctive tropical species (one recorded in the region) of small to medium-sized petrels with stout black bills, long narrow wings, and long, strongly graduated tails usually held closed in a point. Plumage is all-dark with a paler ulnar band, a pattern recalling some large northern storm-petrels.

Family Diomedeidae: Albatrosses

Albatrosses form a well-defined family and differ from other tubenoses in their generally larger size and in having nostril tubes on either side of the bill (see Fig 1). A well-reasoned and widely accepted review by Nunn et al. (1996) identified four recent genera of albatrosses (Fig 17), all of which have occurred in North America: the North Pacific *Phoebastria* (short-tailed albatrosses) and three southern hemisphere genera: *Diomedea* (great albatrosses), *Thalassarche* (mollymawks), and *Phoebetria* (sooty albatrosses). Moreover, Robertson and Nunn (1998) recommended that 24 albatross species be recognized, a leap from the 12–13 species traditionally recognized and one that has yet to be universally accepted. Although most if not all of these "new" species are probably valid, it is not always possible to distinguish them at sea.

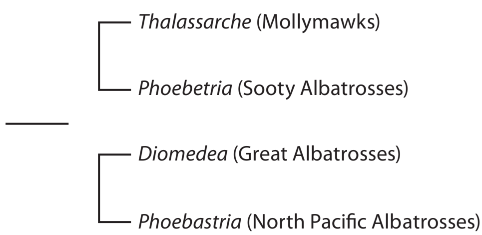

Fig 17. Relationships among present-day albatross genera (from Nunn & Stanley 1998).

Genus *Phoebastria*. Four species of small to medium-large albatrosses with relatively short wings, relatively short tails (the feet project in flight unless pulled in), and generally dull-patterned bills. Ages differ little in three species but strongly in Steller's Albatross. For species identification check overall color pattern, and bill size and color. Three species occur regularly in North America; one is a vagrant.

Genus *Diomedea*. A complex of seven taxa (five Wandering Albatrosses and two Royal Albatrosses). These are the largest albatrosses, with huge bodies, very long and narrow wings, relatively short tails (the feet project in flight unless pulled in), and pale pink bills. Ages differ greatly in Wandering Albatrosses, but little in Royals. For species identification check head and body pattern, upperwing pattern, tail pattern, and details of bill pattern and structure. Northern hemisphere records are exceptional and all are of Wandering Albatross taxa, with only three records in the region, all from the Pacific.

Genus *Thalassarche*. Mollymawks are small to fairly large albatrosses with relatively short wings, relatively long tails (the feet do not project in flight), and brightly patterned bills. Ages differ in appearance; most species attain adult-like plumage aspect in 2–3 years, with fully adult bill pattern taking 4–5 years or longer to develop. For species identification check head and neck pattern, bill color and pattern, underwing pattern, and degree of contrast between hindneck and back. Six taxa of *Thallasarche* have occurred in North American waters.

Genus *Phoebetria*. Two species of striking, all-dark, angular albatrosses with long pointed wings and tails and dark bills; one has occurred as a vagrant in North America. Their flight is often spectacular, with higher sailing glides and steeper arcs than other albatrosses, and the wings are typically crooked strongly. Ages differ slightly in appearance. For species identification check overall plumage contrast, head and bill shape, and bill pattern.

Family Hydrobatidae: Northern Storm-Petrels

Storm-petrels appear to be the earliest divergences from the ancestral tubenose lineage and traditionally have been treated as well-defined southern and northern subfamilies. Recent genetic evidence, however, suggests these are better considered distinct families (Nunn & Stanley 1998; see Fig 12), and they are treated here as such. Only 3–4 genera (but 24 or more taxa, at least 19 of which have occurred in North American waters) are recognized among northern storm-petrels.

Genus *Hydrobates*. Comprises two taxa (British and Mediterranean storm-petrels) sometimes treated as separate species. *Hydrobates* are distinctive tiny storm-petrels with relatively rounded wings, a slightly rounded tail, bright white rump band, white underwing stripe, and hurried flight.

Genus *Oceanodroma*. The largest genus of northern storm-petrels, comprising 18+ taxa worldwide (one presumed recently extinct), with 12+ found in the Pacific, 4+ in the Atlantic, and 2 in both oceans. *Oceanodroma* differ from southern storm-petrels in their longer-armed, more crooked, and relatively narrower wings, and in their shorter legs and smaller feet, which are not habitually used to kick off from the sea surface; the bill, legs, and feet are black. *Oceanodroma* are medium-sized to large storm-petrels with relatively squared heads and relatively long tails, which are forked or notched; the tarsus is usually shorter than the middle toe, and there is often a strong gray gloss to the fresh dorsal plumage.

Six *Oceanodroma* taxa are dark-rumped (Ashy, Chapman's, Markham's, Tristram's, Swinhoe's, and the extralimital Matsudaira's), as are some Townsend's [Leach's]; 9+ taxa are white-rumped (5+ taxa in the Band-rumped complex plus Leach's, Ainley's [Leach's], the extinct Guadalupe, and some Townsend's), and 3 are handsomely patterned and distinctive (2 subspecies of Fork-tailed, plus Hornby's). The Band-rumped Storm-Petrel complex may be distinct enough to comprise its own genus, *Thalobata* (Penhallurick & Wink 2004), and the strikingly distinct Hornby's Storm-Petrel has yet to be investigated genetically. For at-sea identification note overall size, flight manner (relative to wind conditions), tail length and shape, and details of any white rump patches and pale upperwing bands. Bill size and shape can be helpful for identification, and are best evaluated from photos.

Genus *Halocyptena*. This includes at least four taxa of the eastern Pacific (Least, Black, and two Wedge-rumped taxa), all of which have at times been subsumed into *Oceanodroma* but which are distinct enough to warrant separation (Nunn & Stanley 1998). Relative to *Oceanodroma*, *Halocyptena* have small, rounded heads, long legs (tarsus usually longer than middle toe), short tails, sooty plumage (with only a slight gray sheen dorsally in fresh plumage), and deep wingbeats. They often feed and raft in fairly tight-knit groups, and patter over food much like Wilson's or European storm-petrels. Two taxa of *Halocyptena* (Least and Black) are all-dark, whereas the two Wedge-rumped taxa (which might best be treated as separate species) are white-rumped.

Family Oceanitidae: Southern Storm-Petrels

The southern storm-petrels are outwardly more diverse than are northern storm-petrels, with 17 taxa in 5 genera (5–6 taxa of 3 genera have occurred in North American waters). Relative to northern storm-petrels the southern genera have short-armed, relatively broad wings well suited for sailing, and longer legs and bigger feet often used to kick off from the sea surface. As among northern storm-petrels there are some well-marked subspecies, a few of which might better be treated as species (such as northern hemisphere White-faced Storm-Petrels, and all taxa of White-bellied Storm-Petrel).

Genus *Oceanites*. Four or more taxa (two of which, Wilson's and Fuegian [Wilson's], have been recorded in the region) make up this genus of small storm-petrels; all four taxa might better be considered full species but critical studies are lacking. These species have almost triangular wings, slightly rounded tails, and yellowish foot webbing. All have white uppertail coverts and differ mainly in underpart patterning and size.

Genus *Fregetta*. Six or seven taxa (one recorded in the region) of medium-sized to fairly large and broad-winged storm-petrels that suggest *Oceanites* in shape but differ in their broader toes and spade-like claws. All have white uppertail coverts (except some "dark-rumped" White-bellied in polymorphic populations) and white bellies.

Genus *Pelagodroma*. The six taxa of White-faced Storm-Petrel (2–3 recorded in the region) are medium-large storm-petrels with broad, slightly paddle-shaped wings, broad cleft tails, and long legs that often dangle as birds sail-kick along low over the sea.

FIELD IDENTIFICATION OF TUBENOSES

Although what follows may seem an almost overwhelming amount of information to digest, there's no rush. Time spent watching tubenoses and gaining experience is a key to identifying them with confidence. And still, even the most experienced observers can be fooled by observations out of context, or by factors such as atypical lighting, molt, or calm winds for a bird usually seen under windy conditions. As with identifying all birds, a synthesis of characters is important. Don't rely on a single field mark and be especially aware of how flight manner can vary depending on a bird's behavior and on wind strength and direction.

Fine-level details, such as those you might see on shorebirds when studying them with a telescope, are rarely helpful (or even visible) on tubenoses under at-sea conditions, and identification usually rests on size, structure, flight manner, overall plumage pattern, and sometimes other details such as bill structure or foot color. Digital photos can help resolve fine-level details retrospectively. Habitat can also be important (see Ocean Habitats, pp. 5–13), as can an evaluation of environmental conditions such as lighting and distance.

The following sections discuss various things that can aid in at-sea identification of tubenoses, and they provide background to put your observations in context. Armed with this information you are in a position not only to identify the birds you see but to contribute to knowledge about tubenose identification and distribution.

Age, Sex, Individual, and Geographic Variation

When identifying any group of birds it is helpful to know how much inherent variation there is. The good news is that the appearance of most tubenoses varies relatively little with season (except for the effects of wear and fading; see below), and there is no distinct age-related variation in plumage aspect except for some albatrosses (and the extralimital giant-petrels). Thus, at sea, a juvenile female Leach's Storm-Petrel looks like a 20-year-old male Leach's Storm-Petrel. Among albatrosses and petrels, males average larger and bigger billed than females

Fig 18. The relatively stout bill of this Sooty Shearwater (which has recently completed its molt and looks fattened up for migration) suggests an adult male (cf. Fig 19). SNGH. Off Monterey, California, 27 Sep 2008.

Fig 19. The relatively slender bill of this Sooty Shearwater (which has yet to complete its molt) suggests an immature, likely female (cf. Fig 18); such birds can be mistaken for Short-tailed Shearwater but still have a longer and bigger bill than that species, as well as different overall structure and underwing pattern. SNGH. Off Monterey, California, 27 Sep 2008.

(e.g., Einoder et al. 2008), whereas in storm-petrels females average larger, and adults average stouter billed than juveniles, although rarely does this play into identification (Figs 18–19).

Individual variation among some species can be considerable, however, as with a few dimorphic and polymorphic species of shearwaters and petrels, and as with rump patterns in the Leach's Storm-Petrel complex. Even among species that are usually considered rather uniform in appearance there can be appreciable variation in appearance, compounded by molt and plumage wear (Figs 20–23).

Leucistic tubenoses (i.e., birds with white or pale patches where the plumage should be dark) are sometimes seen and can be puzzling (Figs 24–25), whereas albinos (all-white birds with pink bills) are rare and look odd enough to stand out as abnormal. Melanistic tubenoses (i.e., birds with abnormal dark pigmentation) are rare, and melanism has only been reported in a few species of shearwaters (Davis & Packer 1972, Bried et al. 2005, Howell 2007b). In cases of leucisim and melanism, check structure and flight manner to resolve identifications.

Some species of tubenoses exhibit geographic variation that may be consistent enough for subspecies to be distinguished, such as by differences in wing length or bill size, less often by slight differences in plumage patterns. Whether one treats such populations as species or subspecies is a matter of opinion (see Taxonomy and an Identification Framework, pp. 14–21). For the 70 or so species treated here, geographic variation at the level of described subspecies (some of which may prove to be species) is recognized in 2 species of shearwaters (Audubon's,

Fig 20. Sooty Shearwater with unusually white underwings and virtually unstreaked primary coverts. The underwing pattern of most Sooties falls between this extreme and Fig 21. SNGH. Off Monterey, California, 1 Oct 2006.

Fig 21. Sooty Shearwater with unusually dark underwings (cf. Fig 20). SNGH. Off Bodega Bay, California, 12 Jul 2007.

Fig 22. Fresh-plumaged juvenile Sooty Shearwaters, somewhat lean after their transequatorial migration, look rather different from older birds completing their molt (cf. Fig 23). SNGH. Off Hatteras, North Carolina, 29 May 2008.

Fig 23. Completing its molt (the tail is not fully grown), this fresh-plumaged adult Sooty Shearwater is fattening up for migration (cf. Fig 22). SNGH. Off Monterey, California, 14 Sep 2008.

Fig 24. Leucistic tubenoses, like this Ashy Storm-Petrel, can be puzzling and sometimes exhibit patterns that suggest other (much rarer!) species. DLS. Off Santa Cruz, California, 5 Oct 2008.

Fig 25. This leucistic albatross has a bright pink bill (which might suggest Steller's Albatross to the optimistic observer) but its overall size, structure, and bill size are typical of Black-footed Albatross. SNGH. Off Santa Barbara, California, 15 Nov 2009.

Wedge-tailed), 3 petrels (Kermadec, Tahiti, Northern Fulmar), and 5 storm-petrels (Wilson's, Leach's, Wedge-rumped, Fork-tailed, White-faced).

Flight Manner

Tubenoses are usually seen in flight or on the water. Although on-the-water behaviors may at times be helpful for identification, *it is flight manner that defines most tubenoses* (Fig 26). The following is an overview of this essential aspect of tubenose identification, but there is no substitute for at-sea experience when it comes to learning how different species fly. In general, flying tubenoses are either foraging, transiting (moving to and from feeding and nesting areas, including migration), or taking evasive action (freak-out flight) in response to ships or predators such as skuas.

Many tubenoses are highly accomplished fliers largely because they need to travel long distances in search of food. This is due partly to the limited number of predator-free nesting sites, which do not always adjoin the best feeding areas, and partly to the inherently shifting character of marine habitats. The different wing morphologies and flight manners of tubenoses correlate strongly to life history traits such as geographic distribution, colony location, dispersal distances, and foraging behavior (Spear & Ainley 1997).

In general, flight manner relates to wind direction, wind strength, bird behavior, and wing morphology. Wing morphology can be described by two ratios: wing-loading (body mass

Fig 26. In moderate to strong winds, Sooty Shearwaters often tower in high arcs and race across the sky, whereas in calm conditions, or when molting, they usually fly low to the water (Fig 29). SNGH. Off Monterey, California, 26 Sep 2008.

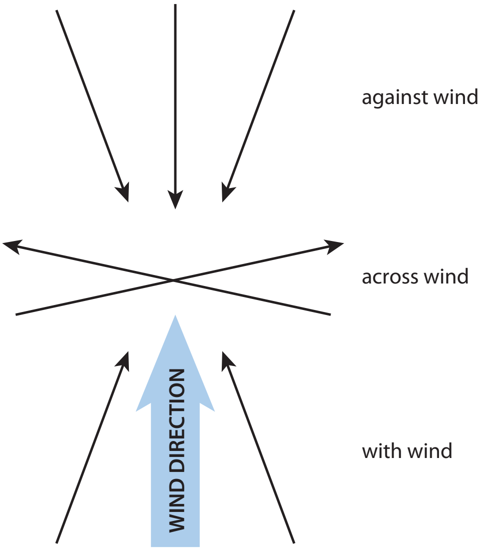

Fig 27. Diagrammatic representation of flight directions relative to wind direction. The main directions are into the wind (when birds often tack and stay fairly low) and across the wind (when birds can sail and wheel, at times very high above the sea, especially with the wind from slightly behind). Few birds fly with the wind blowing directly from behind.

relative to wing area) and aspect ratio (wing length divided by width). Lighter-bodied and broader-winged birds have lower wing-loading and lower aspect ratios, and they fly more buoyantly than do heavier-bodied and narrow-winged birds, which have higher wing-loading and higher aspect ratios.

The flight of tubenoses can be likened to sailing, but unlike inert canvas sails the birds use the undersides of their wings as sentient, self-adjusting sails to catch and manage the wind. In general, there are three modes of flight relative to wind direction—into the wind, across the wind, and with the wind (Fig 27). Unlike ships, however, birds don't have sails that can catch the wind when it blows from directly behind and so they tend to avoid this flight direction. Using the wind to sail is more energy-efficient than wing-flapping, particularly for heavy-bodied birds, which helps explain, e.g., why present-day albatrosses occur mainly in the windy Southern Ocean, where there is an uninterrupted 360° flow of wind around the planet, and not in the relatively confined North Atlantic Ocean.

To conserve energy, transiting birds generally flap as little as possible and sail directly across the wind or sail in a zigzag manner with the wind (as a sailing vessel jibes) or into the wind (as a sailing vessel tacks). Foraging birds may need to travel less quickly if they are seeking food visually and so they often fly into the wind, which usually involves slower flight with more prolonged flapping and shorter glides.

The most efficient flight is across the wind, by *dynamic sailing* (also called dynamic soaring). This flight mode can be seen in almost all tubenoses from Leach's Storm-Petrel to Wandering Albatross. When employed with maximum efficiency, as done by albatrosses in windy regions, birds can fly for hours without flapping, as follows. While flying across and slightly into the wind a bird tilts its underside up into the wind, the undersides of the wings catch the wind, and the bird sails up. At some point gravity will limit the height of the climb (birds climb higher in windier conditions). At the apex of the climb the bird tips its wings down so the wind flows across the uppersurface of the wings, and the bird glides down to near the sea surface. Then it tilts again and catches the wind to sail up, then glide down, on and on. If the wind is not strong enough, or the flight direction is not perfectly matched to wind direction, the bird often compensates or corrects by flapping a little at the bottom of the glide or even in the climb; in contrast, a ship's sails flap, or luff, when not fully filled with wind, which is an indication for the sailor to adjust the sails.

Sometimes a bird levels out at the apex of the climb and glides along high up, at other times it stalls and flaps at the apex before gliding down, perhaps to adjust its direction. Between arcs a bird often glides and banks low over the sea for some distance before sailing up again, so the flight progression is not simply a straightforward rollercoaster. Often the climb is steeper than the descent, and the apparent flight path (e.g., steepness of climb) will depend on the angle of the observer relative to the bird's flight direction. For example, a bird flying perpendicular to an observer's line of vision will show a "truer" path than one that is flying toward or away from the observer.

Because a bird rises with its underside facing into the wind, if it is downwind of you when it rises you see its underparts on the climb; but the reverse will be true if it is upwind, when its upperparts face you as it sails up (Fig 28). Thus, if a large shearwater downwind of you sails up and looks all-dark (i.e., on the underside) then it could be a Flesh-footed; but if a large shearwater upwind of you sails up and looks all-dark then you are seeing the upperparts, which

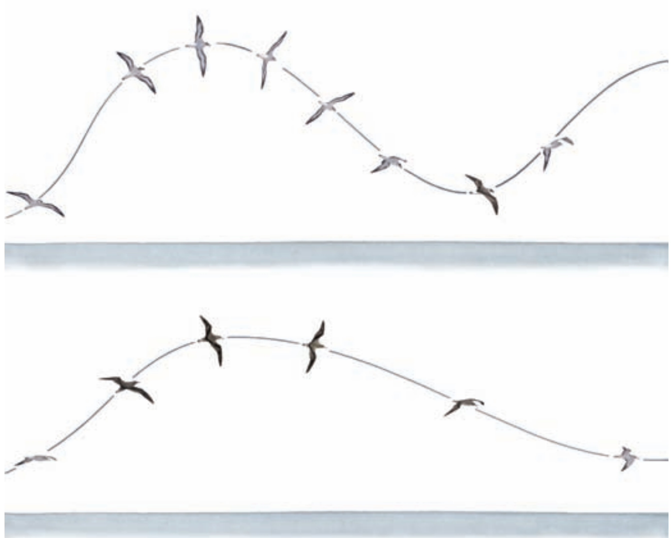

Fig 28. Birds flying across the wind that are downwind of an observer will bank up into the wind and show their underside as they climb, tip at the top of the arc, and show their upperside on the descent. Conversely, birds upwind of an observer on the same flight path will show their upperside on the climb and underside on the descent. Also note the steeper and shorter arcs of Black-capped Petrel (upper image) vs. the lower and longer arcs of the heavy-bodied Cory's Shearwater (lower image). © Ian Lewington. Also cf. Fig 29.

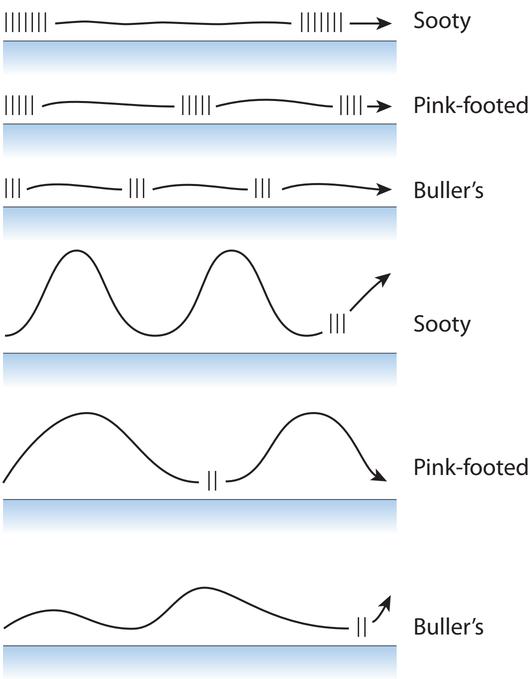

Fig 29. Diagrammatic representation of flight manners of Sooty, Pink-footed, and Buller's shearwaters in calm and strong winds (short vertical lines represent bursts of wingbeats). In calm, the heavy-bodied Sooty proceeds with hurried bursts of deep wingbeats followed by relatively long, low glides, whereas the light-bodied Buller's proceeds with a few quick, flicking wingbeats followed by relatively short, buoyant glides. Across a strong wind, Sooty towers high and steeply whereas Buller's wheels relatively low to the water. With its intermediate wing-loading, Pink-footed Shearwater flies between these extremes.

are uninformative (at least for Pink-footed vs. Flesh-footed). All else being equal, birds with higher wing-loading (e.g., Sooty Shearwater, Great Shearwater, Mottled Petrel) wheel higher and more steeply than birds with lower wing-loading (e.g., Buller's Shearwater, Cory's Shearwater, Galapagos Petrel). Also, when a bird tacks it tends to stay lower than when it jibes or sails across the wind.

In calm or light winds, flight manner can be very different from when it's windy. Many species (especially albatrosses and species with high wing-loading) track winds and do their best to avoid becoming becalmed, when they often simply sit on the water and wait for wind. Thus, migrating Sooty Shearwaters track winds around the Pacific and fly about 65,000 km on their round-trip migration (Shaffer et al. 2006), a distance more than 3 times greater than that offered by a direct route to and from their breeding and nonbreeding areas. Other species of generally calmer tropical waters have low wing-loading and are better suited to fly with less wind, e.g., Bulwer's Petrel. The structural and aerodynamic characteristics of Bulwer's Petrel and Sooty Shearwater, which represent extremes, are common to species in tropical and temperate regions, respectively (Spear & Ainley 1998). Basically, tropical tubenoses range widely over warmer, food-poor environments with lower wind speeds and feed mainly by seizing more mobile prey from the surface, for which a lighter body and broader wings are well suited. Conversely, temperate tubenoses inhabit colder, windier environments with food-rich areas, where they dive for less mobile prey, for which a heavier body and narrower wings are better suited.

In calm conditions, shearwaters usually fly low over the surface by bursts of flapping interspersed with short glides, sometimes seeming to glide low over the surface on a cushion of air trapped under the wings. Species with lower wing-loading (such as Buller's Shearwater) flap less quickly, glide more frequently, and have an easier, more buoyant flight; species with a higher wing-loading (such as Sooty Shearwater) flap quicker, glide less frequently (but often for longer distances), and have a more labored, hurried flight (Fig 29). Thus these two species, which have similar total lengths and wingspans, fly quite differently because of their different morphology.

In winds of 25–30 knots and greater, almost all species of shearwaters and petrels can wheel high and exhibit the classic rollercoaster flight associated with *Pterodroma* petrels. However, only those species with high wing-loading (such as Sooty Shearwater and Mottled Petrel) seem to cut the winds and tower comfortably, whereas species with lower wing-loading (e.g., Buller's Shearwater and Fea's Petrel) tend to stay lower, presumably because their lighter bodies and bigger wings make it more difficult for them to control high flight in strong winds. Low wing-loading also makes birds disproportionately susceptible to being swept inland by tropical storms; hence relatively large numbers of *Pterodroma* petrels compared to shearwaters turn up inland in eastern North America after hurricanes.

So, next time you're on a pelagic trip, or even watching tubenoses from shore, don't just identify the species and move on. Watch the way a bird flies and relate it to the wind speed, wind direction, and behavior—and soon a whole new world of field marks may open up to you.

Environmental Factors

Factors that work directly on the bird include bleaching (color loss through exposure to sunlight), wear (the physical abrasion of feathers), and discoloration from staining, such as from petroleum oil spills. Indirect environmental factors, which affect what an observer sees, or believes he or she sees, include lighting, distance, and wind conditions.

Bleaching and wear work together to cause the deterioration of feathers so that plumage needs to be replaced by molt (see Molts, Plumages, and Aging, pp. 38–45). The most extreme cases of bleaching are usually apparent on birds in their second plumage cycle, when retained juvenile feathers can be very bleached or worn (see P37a.6). In most tubenoses, bleaching and wear can cause birds to look odd, or atypical, but generally not to the extent that species identification is a problem. An exception might be that of bleached Ashy Storm-Petrels, which can look unusually pale in strong sunlight and thus might be mistaken for Fork-tailed Storm-Petrels.

In general, and given the same lighting conditions, fresher feathers are grayer and often look reflective, or frosty, whereas worn feathers tend to be browner and duller, without strong sheens. Observers familiar with a species in worn plumage may be surprised to see how different it appears in fresh plumage; e.g., fresh and frosty Pink-footed Shearwaters have been mistaken for Buller's Shearwaters, and Buller's Shearwaters in worn plumage look rather different than they do in fresh plumage (Figs 30–31).

The importance of lighting and distance to evaluating an observation at sea cannot be overemphasized (Figs 32–35). Most tubenose misidentifications result from misjudging size, which is all too easy without familiar frames of reference, or from illusions resulting from a combination of distance and lighting. The best lighting is with the sun relatively high in the sky (more than 45° above the horizon) and at one's back, preferably with high clouds to reduce glare; cloudier skies and paler gray seas are best for spotting birds, but patterns and colors can be difficult to discern; partly blue skies and seas allow patterns and colors to be seen (and are better for photography), but birds are more difficult to spot against such backgrounds. Bright overcast skies tend to shadow underwings and increase the apparent width of black underwing margins (such as on *Pterodroma* petrels). Conversely, low-angle sun early and late in the day heightens contrast, and sun glare often bleeds out white areas and makes them appear more extensive (Fig 36), such as those on underwing margins or the rump patches of storm-petrels; this is particularly true when observers are close to the sea surface such as on smaller boats. Thus, e.g., Black-vented Shearwaters early and late in the day can appear bright "black-and-white" and be mistaken for Manx Shearwaters (Fig 37); or Pink-footed Shearwaters can appear to have dark caps and bright white underwings, inviting confusion with Buller's Shearwater. Given low-angle sun in mostly cloudy to overcast conditions a Leach's Storm-Petrel appears black with a bright white uppertail-covert band, but under high-angle sun with high clouds and

Fig 30. Buller's Shearwater in fresh plumage, showing the bright pattern familiar to West Coast pelagic birders. SNGH. Off Monterey, California, 22 Sep 2007.

Fig 31. Buller's Shearwater in worn plumage, appearing much browner and less contrasting than typical of West Coast migrants. SNGH. South Island, New Zealand, 27 Mar 2008.

diffuse light the same bird appears warm dark brown, and dusky markings may be apparent on the duller-looking white uppertail coverts. Moreover, a bird's position relative to the sun angle and to an observer can cause its appearance and color tones to change in a matter of seconds (Figs 38–39).

All observers have a distance beyond which they cannot identify a bird, and this distance generally increases with experience. However, most observers tend to underestimate distance and believe, e.g., that a bird 500 m distant is only 200–300 m away; clearly, this will have implications for judging size or for believing what features should be visible at a given distance. If a bird is simply too far away to identify, then there is little to be gained by watching it. Remember, distance is the great deceiver and imagination the great receiver—more can be learned by studying closer birds. Conversely it is very helpful to watch, say, a close Pink-footed Shearwater or Great Shearwater and follow it into the distance. At the limits of visibility it will still be the same species, even though you can no longer see the features you used to identify it when it was close. In this way you can absorb subtleties of flight manner, shape, and overall pattern, which can improve your pelagic birding skills greatly.

Size judgment of birds at sea, particularly lone birds, can be difficult at best. Even very experienced observers can be fooled easily by a lone bird, especially one out of context. The sea has no yardsticks, and estimating wave and swell heights at a distance is fraught with potential for misjudgment. If you watch seabirds from different size vessels then you will also need to calibrate your size impressions for the size of a vessel and your height above the sea. For example, from a small boat in gentle seas a Black-footed Albatross can look really big to an observer low to the water, as might even be true of a Black Storm-Petrel in calm conditions. But from high up on a larger vessel, the same albatross can look deceptively small, especially if viewed against a seascape of big swells and impressive waves, and the storm-petrel might not even be visible. Fog decreases the visible horizon, which can increase the apparent size of a bird.

Wind is another important environmental factor that relates to at-sea identification of tubenoses—as well as to their distribution. For example, wind is actually a "habitat" favored by albatrosses and other heavy-bodied species that experience difficulty flying in calm conditions. Wind speed and relative direction can greatly affect how a bird flies (see Flight Manner, above), not to mention how well an observer can see and watch a bird if he or she is being buffeted and coated with salt spray!

Appearance and Topography

Being able to accurately describe and understand what you see are essential steps in any identification process. Because good close-range views of many tubenoses tend to be brief, observers should learn to appreciate the overall structure and plumage patterns of birds viewed at a distance before worrying about details such as how deeply a tail may be forked.

Overall Size and Structure

Even without other species for comparison it is relatively easy in almost all cases to place a tubenose into the category of small (storm-petrel), medium (petrel/shearwater), or large (albatross) (see Figs 13–15). Finer-level distinctions within these groups can be more difficult but are often a fundamental first step in any species-level identification. Such evaluations are best achieved with other species for comparison. For example, a lone Black-vented Shearwater might be confused with the much larger Pink-footed Shearwater based simply on similarities in plumage pattern, but the size difference would be apparent if the species were together or if another known species were present for comparison, such as a Sooty Shearwater (bigger than Black-vented, smaller than Pink-footed).

Fig 32. In low-angle backlighting, the white underwing panels of a Sooty Shearwater are muted but nonetheless contrast distinctly with the dark remiges (cf. Figs 33–35). SNGH. Off Bodega Bay, California, 24 Sep 2006.

Fig 33. In low-angle lighting, only minutes after Fig 32 was taken, the white underwing panels of a Sooty Shearwater flash bright silvery white and the whole bird appears paler overall (cf. Figs 36–37). SNGH. Off Bodega Bay, California, 24 Sep 2006.

Fig 34. Even in light fog and low-angle lighting the white underwing panels of a Sooty Shearwater can be striking (cf. Figs 32–33, 35). SNGH. Off Bodega Bay, California, 24 Sep 2006.

Fig 35. In thicker fog, the white underwing panels of a Sooty Shearwater can disappear altogether (cf. Figs 32–34). Notice the overall dark aspect, relatively slim body, and narrow wings, which distinguish this silhouette from that of a Northern Fulmar. SNGH. Off Bodega Bay, California, 24 Sep 2006.

Fig 36. Two light morph Wedge-tailed Shearwaters showing how direct sunlight and a slight difference in angle can wash out the contrast between the white coverts and "dark" remiges. SNGH. Western Pacific, 20°N, 147°E, 19 Apr 2007

Fig 37. Bright, low-angle sunlight can transform the normally muted plumage contrasts of a Black-vented Shearwater into a contrasting pattern that could suggest Manx, Newell's, or Townsend's shearwaters. Note lack of a discrete dark thigh patch, dusky markings on undertail coverts. SNGH. Off Baja California, Mexico, 12 Sep 2006.

Figs 38–39. These two images of an individual juvenile White-faced Storm-Petrel in fresh plumage, taken within a minute of each other, illustrate how lighting can dramatically—and quickly—change apparent plumage tones. SNGH. Off Hatteras, North Carolina, 28 Jul 2007.

Structural features that lend tubenoses distinctive shapes are their wing length and wing width, tail length and shape, head size and shape, and body size relative to wing area. Such differences are not always conveyed easily by standard measurements. Although simple linear measurements of Buller's Shearwater (L 43–45.5 cm, WS 96–104 cm) and Sooty Shearwater (L 43–45.5 cm, WS 97–106 cm) almost completely overlap, these two species are quite different in shape because Buller's has a longer neck, longer tail (115–135 mm vs. 83–97 mm in Sooty), and distinctly broader wings, and it weighs much less (around 425 g vs. 800 g for Sooty).

At sea it is often difficult to disassociate size, structure, and behavior because, all else being equal, larger birds have slower wingbeats than do smaller birds. However, failure to uncouple these aspects can sometimes compromise size perceptions, particularly if comparisons are made with different wind speeds or even wind directions. For example, in calm or light winds, or even when flying into a moderate wind, the languid flapping of a Black Storm-Petrel translates to "large size." But when the same bird is sailing quickly across moderate winds it may give only occasional, relatively quick and shallow wingbeats, which can cause it to appear smaller, more like a Chapman's Storm-Petrel.

If confronted by an unfamiliar tubenose, try to evaluate its overall structure in terms of wing length relative to wing width, tail length relative to wing width (is the tail longer or shorter than the width of the wings at the body?), and head and neck projection relative to tail projection (is the head and neck projection forward of the wings shorter than, longer than, or similar to the tail projection behind the wings?). Other structural characters (see below) can be helpful, such as forehead shape (gently sloping, steep, bulbous, etc.), bill shape (relatively thick, slender, long, etc.), and tail shape (squared, strongly graduated, deeply forked, slightly notched, etc.), but these details should be built upon the overall shape.

Plumage Patterns

For better or worse, most tubenoses are hued in shades of blackish, dark brown, gray, and white, and most are either dark above and white below, or all-dark. Dark areas tend to be blacker or grayer when fresh and then fade to browner, and their apparent tones can be greatly affected by lighting: dark browns look cold and blackish in overcast lighting but warm and even gingery in bright sunlight (see P6.11–P6.12). The dark undersides of the remiges and greater coverts on several species have a reflective sheen, the strength of which varies greatly with angle of lighting.

On any unfamiliar all-dark tubenose check for any underwing flashes and any other areas of contrast, as well as noting overall structure and bill color. On "black-and-white" tubenoses check the width and distribution of any dark underwing margins (beware of lighting effects) and the color of the undertail coverts (dark or white?). The pattern and extent of dark on the head and neck sides is also helpful for distinguishing some species (such as Hawaiian and Galapagos petrels, or Townsend's and Galapagos shearwaters) but has to be evaluated carefully. As viewed from above, dark head and neck sides often appear as a cowl or a bulge on the chest sides, but viewed from below the same pattern can appear as a shallow dark cap (see P28.2 vs. P28.7); a good side-on view is best for determining head and neck patterns.

On storm-petrels, it can be important to note the shape and size of the pale upperwing band and the shape and extent of any white rump patch. For example, on Leach's Storm-Petrel the upperwing band tends to widen toward the front edge of the wing and it usually reaches the wing bend; on Grant's [Band-rumped] Storm-Petrels the ulnar band is shorter, is more even in width, and usually does not reach the wing bend. The white rump patch on Leach's is often longer than wide, is slightly *U*-shaped, and does not wrap around the sides of the undertail coverts; the white band on Grant's [Band-rumped] is typically wider than long, tends to be more parallel sided, and wraps around to the lateral undertail coverts.

Topography

An understanding of topography is important for being able to describe accurately what you see. Tubenoses have the same general structure as most birds, but some of the proportions differ, especially the wings of longer-winged species. The general features of tubenose topography are shown in Figs 40–46.

Tubenoses on the water look very different from tubenoses in flight (Figs 42–43). On a swimming tubenose you basically see the head, neck, chest, flanks, "upperparts" (including the closed wings and the tail), and undertail coverts. The undertail coverts of most tubenoses are notably long and full, covering much of the tail. The wings are folded so that mostly what you see are the coverts (which cloak the secondaries) and the projecting tips of the outer primaries, which lie over the tail. On longer-winged species with a long humerus (see below), the elbow sticks up and creates a variable hump on the back.

Unlike most birds we see every day (such as songbirds, gulls, and ducks), many of the larger tubenoses (especially albatrosses) have a relatively long humerus (the upper arm bone). This results in a "double-jointed" wing, with a bend at the elbow (between the humerus and ulna) as well as the usual bend at the wrist (between the carpal joint, where the primaries are attached, and the ulna, where the secondaries are attached) (Fig 42). At the other extreme among tubenoses, the southern storm-petrels (such as Wilson's) have a short ulna, which results in an almost triangular, swallow-like wing shape.

Tubenoses have ten *primaries* (p), or primary flight feathers. These are attached to the hand bones and are numbered outward. Thus p1 is the short innermost primary and p10 the long outermost primary. As the wing closes, the bases of outer primaries slide under the inner primaries and the primaries overall slide under the secondaries and tertials. Mostly what you see of the primaries on a closed wing is the tips of the outer primaries. The *wing projection* is the projection of the wingtip beyond the tail tip, which can be helpful for some identifications. When evaluating wing structure, beware of pitfalls provided by birds that are molting their outer primaries; e.g., a Sooty Shearwater with the outer primaries not fully grown can look relatively short- and blunt-winged, inviting confusion with Short-tailed Shearwater.

The *secondaries* (s), or secondary flight feathers, are attached to the ulna bone of the forearm. Secondaries vary in number among species (from 11 in small storm-petrels to 38 in large albatrosses) and are numbered inward; thus s1 is the outermost, adjacent to p1. The innermost secondaries are called tertials, which are elongated feathers that act as coverts for the closed wing.

On most birds the humerus bone is short and any feathers associated with it are small and not really noticeable; thus the tertials slide under and merge with the scapulars where the wing meets the body. However, because long-winged birds such as albatrosses have a long humerus they have an "extra" stretch of wing, which lies between the secondaries (and their coverts) and the scapulars. The *humerals* are the long, fairly strong wing feathers that fill the "gap" between the secondaries and the scapulars (the tertials slide under them), and they are overlain by humeral coverts (Fig 42).

The *greater secondary upperwing coverts* (often just called greater coverts) mostly or completely conceal the secondaries on resting birds (Fig 43). The coverts immediately above the greater coverts are usually termed *median coverts*. (For simplicity I follow this convention here, but note that "median coverts" are not homologous feather groups across species: on tubenoses they are ostensibly a second row of greater coverts while on songbirds they are simply the largest lesser coverts.)

The *scapulars* are a group of feathers that originate from a point at the base of the humerus. They fan out to protect the base of the wings at rest and form a seamless join between the wings and body in flight (Figs 41–42).

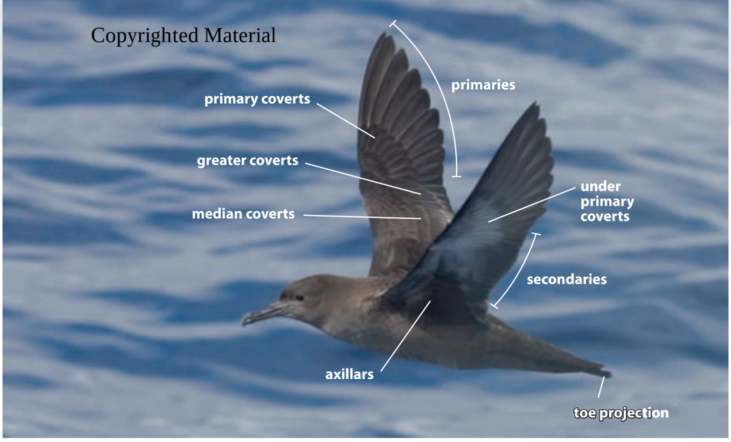

Fig 40. Juvenile Sooty Shearwater. Note how p10 is appreciably narrower and more tapered than the other primaries, something common to many juvenile petrels and albatrosses. SNGH. Off Cape Hatteras, North Carolina, 25 May 2009.

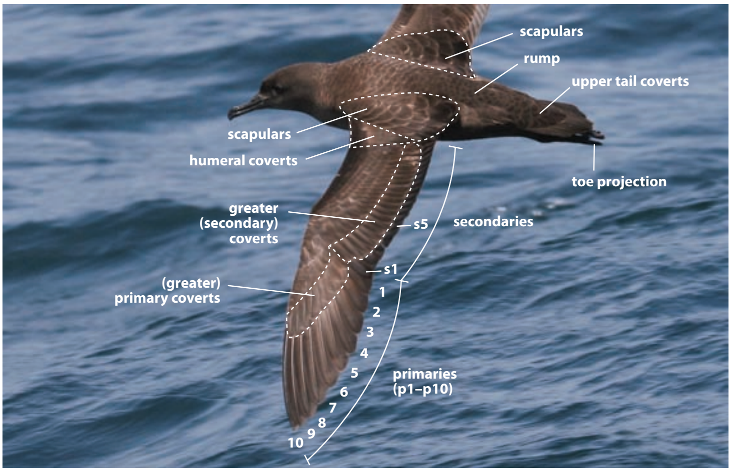

Fig 41. Sooty Shearwater. Subtle contrasts between fresher secondaries and relatively faded primaries and greater coverts indicate a bird older than its first cycle (when all wing feathers would be juvenile, with comparable wear). SNGH. Off Monterey, California, 11 May 2008.

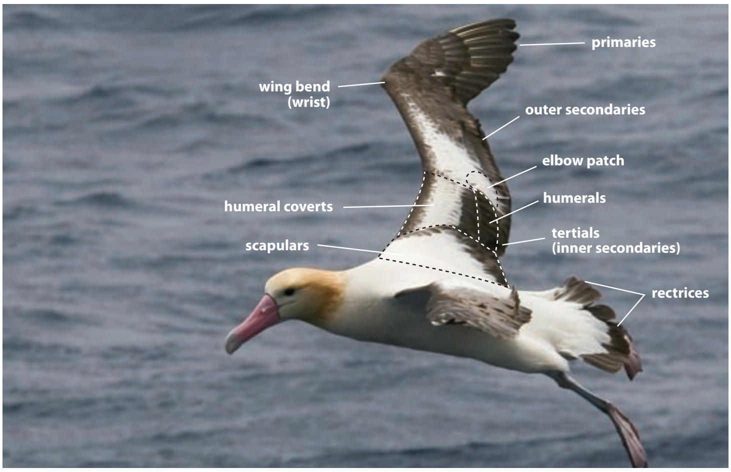

Fig 42. Adult Steller's Albatross. Compare wing anatomy with Fig 43. SNGH. Torishima, Japan, 1 May 2008.

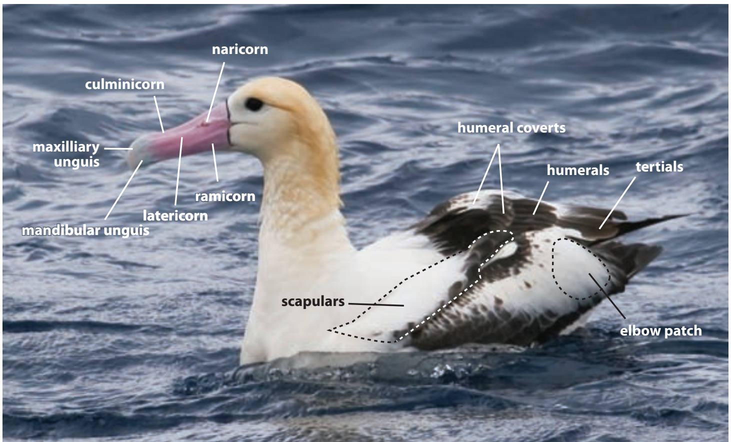

Fig 43. Adult Steller's Albatross. Note how the tertials and humerals bunch up on the closed wing (cf. Fig 42). SNGH. Torishima, Japan, 1 May 2008.

The tails of most tubenoses consist of 12 *rectrices* (r) (the singular of which is *rectrix*), six on each side of the midpoint. Rectrices are numbered outward from the central rectrix (r1) to the outermost rectrix (r6) on each side of the tail (Fig 42). Tail shape and length can be of use in tubenose identification, as well as whether or not the toes project beyond the tail tip. Note, though, that all species can pull in their feet under the relatively long and plush under-tail coverts so that no toes (and no toe projection) are apparent (Fig 44).

In most albatrosses and petrels the tail is slightly to strongly graduated (with the outer feathers progressively shorter), the most extreme examples being the long and strongly graduated tails of Wedge-tailed Shearwater, Bulwer's Petrel, and the sooty albatrosses (genus *Phoebetria*). Tail shape differences among storm-petrels can be helpful for identification but always be aware of how molt and how the tail is held can affect tail shape. For example, if the longest outer rectrices of an Ashy Storm-Petrel are missing, then its tail may look squared or even rounded, inviting confusion with Least Storm-Petrel (see S11.3); or if the outer rectrices of a Leach's Storm-Petrel are worn or molting, its tail can look fairly squared, similar to a Grant's [Band-rumped] Storm-Petrel (see S5.5). Also note that a spread tail can appear relatively squared or rounded, but the same tail held closed can show a notch or shallow fork.

Bill Structure and Color

The bill of a tubenose is covered by a set of horny plates (Fig 43), which are easily seen on species such as Northern Fulmar and albatrosses. Bill size and shape can be important in tubenose identification. Obvious differences are those between the relatively thick bills of medium-sized and larger *Pterodroma* petrels and the relatively slender bills of shearwaters. More subtle differences, best evaluated from photos, are those between the relatively small, slender bill of Ashy Storm-Petrel and the bigger, stouter bill of Black Storm-Petrel. When making some judgments, note that male albatrosses and petrels tend to have slightly longer and deeper, or stronger, bills than females, and that immatures tend to have more slender bills than do adults (see Figs 18–19).

Bill coloration and pattern can be important for identifying some albatrosses and petrels (all storm-petrels and gadfly petrels have basically all-black bills). For example, an easy way to pick out a Flesh-footed Shearwater sitting among Sooty Shearwaters is to look for a bright pink, black-tipped bill (vs. the all-dark bill of a Sooty). Among mollymawks, details of bill color and pattern can be essential for age and species identification. More subtle differences in bill color probably remain to be described and evaluated, such as among the small shearwaters; if such differences prove consistent, they may be invaluable in tricky identifications and may be documented with good photos.

Leg and Foot Color

Details of leg and foot color can be useful for identification but are rarely visible at sea, although they may be captured by photos. In many cases, the feet are tucked into the under-tail coverts and simply not visible. On shearwaters with mostly pinkish or bluish legs and feet the outer or rear edges of the legs and toes are often blackish, which can greatly affect one's perception of leg color (Fig 46). On many gadfly petrels the legs and basal portions of the feet are pinkish or bluish whereas the distal portions of the toes and webs are black, almost as if they have been dipped in ink. On some taxa of small shearwaters, age-related changes in foot color have been suggested (Bretagnolle & Attié 1996), and such variation should be investigated further.

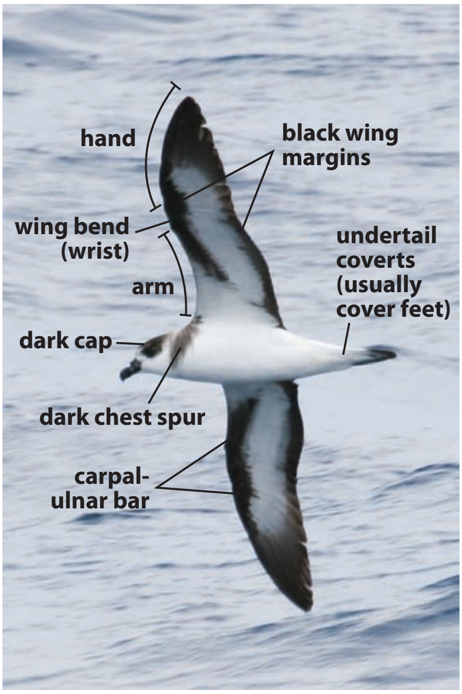

Fig 44. Black-capped Petrel. SNGH. Off Hatteras, North Carolina, 23 May 2008.

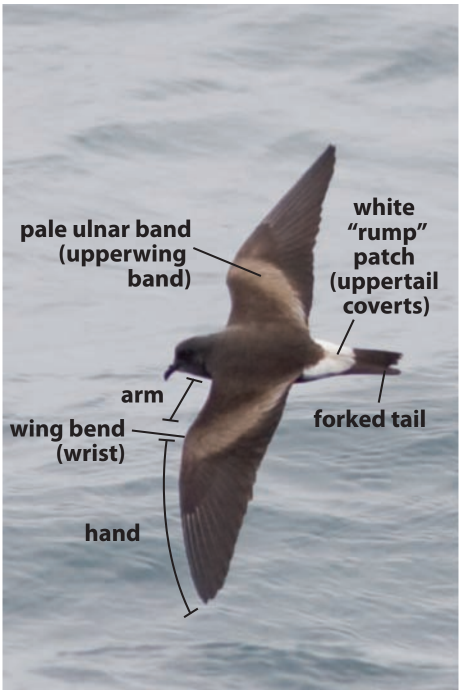

Fig 45. Leach's Storm-Petrel. SNGH. Off Santa Barbara, California, 25 Jul 2009.

Fig 46. Several shearwater species, including Buller's Shearwater, have bicolored legs and feet, with the outer and hind portions being black, the inner and front portions pinkish. SNGH. North Island, New Zealand, 26 Mar 2007.

Molts, Plumages, and Aging

Feathers are not permanent—they wear out and need to be replaced. Molt is simply the normal and regular growth of feathers, by which plumages are attained. As a rule, tubenoses do not molt when they are breeding, and immatures and nonbreeding adults molt earlier than do adults (Figs 47–50). The prebasic molt of breeders can be shorter and finish earlier than that of nonbreeders (as in southern-breeding transequatorial migrants; Figs 47, 49) or can be more protracted and finish later (as in northern hemisphere residents and northern-breeding transequatorial migrants; Figs 48, 50).

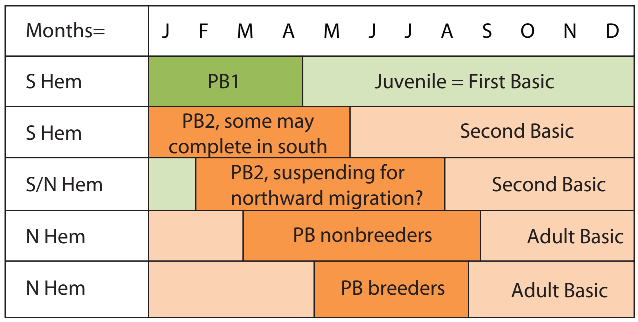

Fig 47. Provisional wing molt schedules for Sooty Shearwater; some postjuvenile molts occur in northern hemisphere (N Hem) but PB2 can start (and perhaps complete?) in first southern hemisphere (S Hem) summer. Green indicates first prebasic (PB1 = prejuvenile) molt in nest; orange indicates subsequent wing molts (PB2 = second prebasic, PB = later prebasic molts); paler tones indicates plumages. Great Shearwater (and perhaps other transequatorial-migrant Ardenna) may be similar.

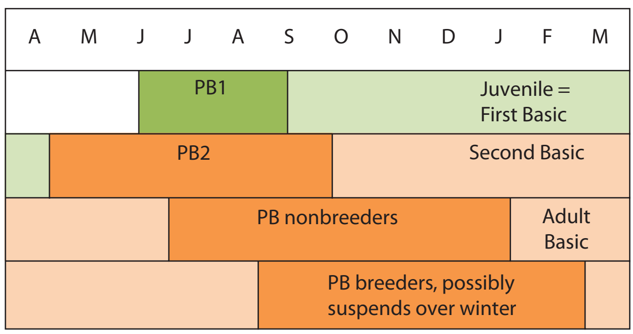

Fig 48. Provisional wing molt schedules for Northern Fulmar; see Fig 47 for key.

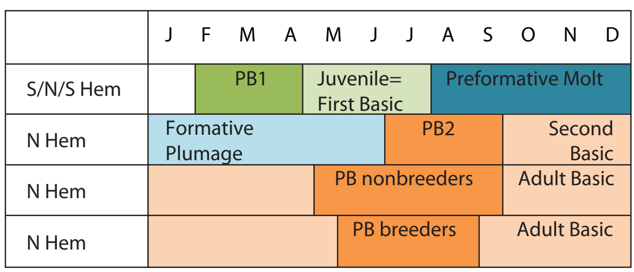

Fig 49. Provisional wing molt schedules for Wilson's Storm-Petrel; see Fig 47 for key; blue indicates (complete) preformative molt. Most postjuvenile molts occur in northern hemisphere but preformative molt can suspend to finish in first southern hemisphere summer.

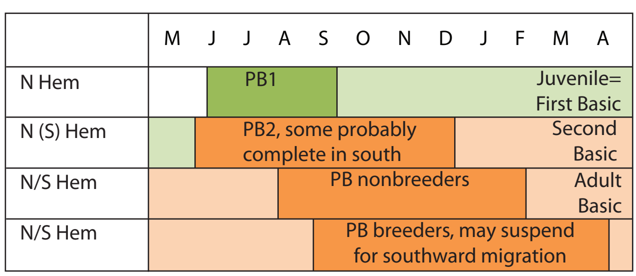

Fig 50. Provisional wing molt schedules for Leach's Storm-Petrel; see Fig 47 for key.

Noting the proportions of molting birds and how far their primary molt has progressed (see below) and nonmolting birds (in worn and fresh plumage, if possible) can provide important information on molt timing, molt duration, and age composition of a population. For example, second prebasic molts start earlier than subsequent prebasic molts except in Wilson's Storm-Petrel, which has a complete preformative molt. Under at-sea conditions it can be difficult to distinguish fresh juveniles from birds that have recently completed molt. For example, some fresh-plumaged Northern Fulmars in October or Black-capped Petrels in August may be juveniles or perhaps in fresh second basic plumage.

As well as aiding in age determination, wing molt timing may also be helpful for species identification if similar-looking species breed at different seasons, as do Cape Verde [Fea's], Desertas [Fea's], and Zino's petrels (Howell & Patteson 2007).

The most conspicuous molt tends to be in the wings, especially among the primaries, and with practice observers should find primary molt quite easy to see and record (Figs 51–58). Among petrels and storm-petrels the primary molt starts with p1 or p2 (NCSM specimens of Black-capped Petrel, and see P20.7; also Pyle 2008) and proceeds out to p10 (the extent to which molt initiates with p1 rather than p2 has yet to be investigated critically). In these species I find it helpful to score wing molt in the field by how far it has progressed in the primaries: are there missing or growing feathers in the inner (p1-p4), middle (p5-p7), or outer (p8-p10) primaries?

Often the inner 3–4 primaries are dropped almost simultaneously, so that there is an obvious gap in the inner wing (Figs 51–52, 55); the middle primaries tend to be molted gradually, 1–2 at a time; the outer primaries may be molted gradually or, in some species, may all be growing at once, which can compromise flight for a short period. Species that molt several outer primaries at once tend to do so because they have only a limited time available for molt, such as long-distance migrants (e.g., Great and Sooty shearwaters) or species with a short period between breeding seasons (e.g., Black-footed Albatross); these birds may feed intensively and fast while molting, and also tend to congregate in food-rich areas where they don't need to fly great distances.

When wing molt has progressed to around p4-p5, many species (such as Black-capped Petrel, Pink-footed Shearwater, and Wilson's Storm-Petrel) synchronously shed most or all of the greater upperwing secondary coverts; species with white bases to the secondaries often show white upperwing stripes at this stage of molt, before the coverts grow out and cover the white bases (Fig 52). The primary coverts are usually molted sequentially, along with each corresponding primary.

The secondaries tend to start molt from at least three points: from s1 and s5 inward and from one or two points among the inner secondaries. The secondaries usually start molt after primary molt has progressed out to the middle primaries. This means birds older than 1 year can often be distinguished by slight contrast between the fresher outer secondaries and the variably worn primaries (and greater coverts); on juvenile birds all feathers grow simultaneously and there is no strong contrast (see Figs 40–41; also see Pyle 2008). Tail molt usually occurs toward the end of, or after completion of, primary molt, and starts with the central rectrix (r1) or sometimes the outermost (r6); r5 is often the last feather to grow.

Albatrosses have novel wing molt strategies (Howell 2006c, Howell 2010b, Rohwer & Edwards 2006), with the primaries being split into two series: p8-p10 molt outward as a series (annually in *Phoebastria*; biennially in southern hemisphere genera), whereas the middle primaries appear to molt inward from p7, perhaps in stepwise waves.

Age Terminology and Plumage Cycles

In this book I use the Humphrey-Parkes (H-P) system of naming molts and plumages, which is based upon plumage cycles and the concept of homology (Howell et al. 2003, 2004,

Fig 51. Sooty Shearwater. In a pattern shared with many other species, most petrels shed their inner primaries almost synchronously, creating a fairly large and obvious gap in the trailing edge of the wing. SNGH. Off Monterey, California, 11 May 2008.

Fig 52. Sooty Shearwater. When molt reaches the middle primaries being shed, most or all of the greater coverts are shed synchronously. This often results in a white stripe on the upperwing, produced by exposed bases to the secondaries. SNGH. Off Monterey, California, 11 May 2008.

Fig 53. Sooty Shearwater. After the new inner primaries and greater coverts grow, molt progresses through the middle and outer primaries (p6 is just starting to grow here). Unlike the greater secondary coverts, primary coverts grow sequentially. Molt in the secondaries proceeds inward from both s1 and s5 (the latter feather replaced on this bird), and outward from the tertials. SNGH. Off Monterey, California, 11 May 2008.

Fig 54. Sooty Shearwater. Molt progresses through the middle and outer primaries as the upperwing coverts, secondaries (s1 and the innermost ss have been shed), and some body feathers are renewed. SNGH. Off Monterey, California, 11 May 2008.

Fig 55. Wilson's Storm-Petrel. As with Sooty Shearwater, the inner primaries usually drop almost synchronously. This bird shows asymmetrical wing molt (not that rare in Wilson's Storm-Petrel): on the far wing, p1-p2 are growing, p3-p4 and the greater coverts have been shed; on the near wing, p1-p3 are new, p4 and the greater coverts are growing, p5 has been shed. SNGH. Off Hatteras, North Carolina, 25 May 2009.

Fig 56. Most adult Wilson's Storm-Petrels complete wing molt by early Sep (compare with Figs 57–58); this bird is growing p9, with p10 shed, and is also molting its secondaries. SNGH. Off Hatteras, North Carolina, 17 Aug 2009.

Fig 57. Wilson's Storm-Petrel is unusual in having a preformative wing molt, which usually starts in late summer or fall, when adults are completing their wing molt (see Figs 49, 56), and may be suspended over southward migration to complete in the southern summer (see Fig 58). SNGH. Off Hatteras, North Carolina, 16 Aug 2009.

Fig 58. Wilson's Storm-Petrel in later stages of presumed preformative wing molt, with p9-p10 old and p8 growing. Such birds presumably complete this molt by austral mid-summer and are in mostly fresh plumage when they migrate north in Apr–May. SNGH. North Island, New Zealand, 8 Nov 2008.

Humphrey & Parkes 1959). In the H-P system only molts produce plumages (plumages are not attained by wear), and the word *plumage* refers to a coat of feathers not to the appearance of the feathers; thus there is a one-to-one correlation of plumages to molts. A plumage cycle (often shortened simply to cycle) runs from a given plumage or molt to the next occurrence of the same plumage and molt. The first plumage cycle extends from the acquisition of juvenile plumage (equivalent to first basic plumage; Howell et al. 2003) to the start of the second prebasic molt. In most tubenoses the juvenile plumage is often not distinguishable in the field from that of older immatures or adults, and molt timing (see Figs 47–50) or state of plumage (fresh or worn) may be the only clues to aging.

Basic and Formative Plumages

As adults, all birds follow a fundamentally similar pattern of plumage succession and have a molt by which most or all of their feathers are replaced. The plumage attained by this complete molt is called *basic plumage* because that's what it is—a bird's basic plumage. The molt by which basic plumage is attained is the *prebasic molt*. In most adult tubenoses the basic plumage cycle is about 12 months long, i.e., an annual cycle. The prebasic wing molt of tubenoses typically occurs between breeding seasons, although molt of body feathers often starts when birds are nesting. Some birds (but no tubenoses, as far as known) have a second plumage added into their basic cycle. This added plumage is called an *alternate plumage*: it alternates with the basic plumage, and it is attained by a *prealternate molt*.

Most species of tubenoses appear to molt straight from juvenile (first basic) into second basic plumage at about 1 year of age. A few species, however, appear to have a novel molt added into their first cycle (i.e., a molt with no counterpart in subsequent cycles); this is called the *preformative molt,* which produces formative plumage. The preformative molt is usually limited to head and body feathers but is complete in Wilson's Storm-Petrel. In *Phoebastria* albatrosses and several species of shearwaters, the body molt starting within 6–8 months of fledging may be a preformative molt but seems more likely to be the start of the protracted second prebasic molt (offsetting the molt of head and body feathers from that of flight feathers would reduce energy demands for when the all-important remiges are replaced). After the first cycle, molts of prebreeding immatures are much like those of breeding adults but average earlier, are more protracted, and, in larger species such as albatrosses, are often more extensive among the primaries and secondaries. This is because the immatures have more time to molt than do breeders, which have only a relatively short period for wing molt between breeding seasons.

Molt Strategies of Tubenoses

The molt strategies of a bird reflect a finely honed balance with other aspects of its lifecycle—mainly breeding and migration—in combination with food availability, environmental conditions, foraging experience, fitness, and the overall size of an individual bird. The main requirement for molt is sufficient and predictable food, which tends to be more abundant in the temperate northern hemisphere during the northern summer. This helps explain why several southern-breeding species (such as Great and Sooty shearwaters) undertake long transequatorial migrations to molt in North American waters at this season; the North Pacific albatrosses also molt in this season. First-year individuals, which are not breeding, typically molt earlier than do adults.

As noted under Flight Manner (pp. 24–28), tubenoses of tropical latitudes tend to have lower wing-loading and range widely over warmer, food-poor environments, whereas tubenoses of temperate habitats tend to have higher wing-loading and inhabit windier, food-rich environments. Tropical tubenoses (such as Wedge-tailed Shearwater and Black-capped Petrel) also tend to have more protracted wing molts during which they maintain good flight capabilities, whereas temperate tubenoses (such as Short-tailed Shearwater and Mottled Petrel) often have relatively rapid wing molts during which they may be temporarily almost flightless but can dive for concentrated prey that fuels a quick molt; reduced wing area during molt may even improve diving proficiency in shearwaters because these birds flap their wings underwater.

Within tubenoses that molt regularly in North American waters, four groups can be identified in terms of breeding latitudes and migrations (Table 5). Like most attempts to draw lines on natural processes these groups do not indicate clear-cut differences, and some species are grouped as subjective best fits.

A. *Northern Residents*. Relatively few species remain year-round in the temperate and subtropical northern oceans, and those that do molt after breeding. The smaller species, petrels and storm-petrels, have protracted wing molts that start in late summer and continue gradually over the winter or may be suspended in mid-winter before completing in spring. The second prebasic molt occurs earlier, mostly during the northern summer when food is plentiful (Fig 48).

The North Pacific albatrosses are a subset of northern residents, but because of their large size they do not have sufficient time to replace all of their flight feathers in the few months available between the protracted breeding seasons. They have compensated for this with a novel strategy whereby the heavily worn outer three primaries are replaced every year, but the less exposed inner and middle primaries are usually replaced over two or more years. In some cases a bird may be unable to replace enough primaries between successive breeding seasons and it will skip a year of breeding to catch up with its molt (Langston & Rohwer 1996). These albatrosses undergo wing molt in late summer and fall, which corresponds to seasonal peaks in food abundance.

B. *Northern Migrants* breed in temperate or subtropical northern latitudes and withdraw to tropical or southern latitudes in the nonbreeding season. Their molts may be suspended for migration, such as with Cory's Shearwater and Leach's Storm-Petrel, which start primary molt while nesting and complete it in winter (Ainley et al. 1976, Monteiro et al. 1996). The second prebasic molt occurs earlier, mostly during the northern summer period of food abundance (Fig 50).

C. *Tropical Migrants* breed in tropical or subtropical latitudes and often range to food-rich areas within the tropics or subtropics to molt, sometimes traveling considerable distances in longitude (such as Wedge-tailed Shearwaters that migrate from Hawaii to western Mexico); several species (such as Parkinson's and Juan Fernandez petrels) are transequatorial migrants, but not to the extent of species in Group D. Mostly these species molt in the "summer season" of either hemisphere (March–September in the northern, September–March in the southern), but there are several exceptions in these relatively aseasonal environments. A notable exception is Murphy's Petrel, which appears to molt in the subtropical North Pacific during midwinter. At least two species occurring in the region (Galapagos Petrel and Galapagos Shearwater) molt year-round, reflecting their year-round breeding schedules. The second prebasic molt generally appears to start a month or two earlier than the adult prebasic molt.

D. *Southern Migrants* are species that migrate from southern temperate or subtropical waters (where they breed) to northern temperate or subtropical waters to molt in the food-rich northern summer (Figs 47, 49). Generally these species have a relatively quick wing molt. The second prebasic molt strategy is variable: some birds molt in the southern hemisphere in late summer, before migrating north; some may spend their first year in the northern hemisphere and molt there slightly earlier than do the adults; and some start molt in the southern hemisphere and suspend it to complete in the northern hemisphere summer. Perhaps because of its relatively weak juvenile plumage, in combination with its long migrations, Wilson's Storm-Petrel has a complete preformative molt, which occurs slightly later than the adult prebasic molt (Fig 49). This strategy parallels that of other transequatorial migrants, such as Long-tailed Jaeger and South Polar Skua.

Table 5. Molt strategies of selected petrels, albatrosses, and storm-petrels that occur in the region (see p. XX). Group A: northern residents; prebasic wing molt in n fall through winter; molt incomplete and mainly during fall in albatrosses. Group B: n migrants; prebasic wing molt mainly in n winter on tropical or s nonbreeding grounds. Group C: tropical migrants; prebasic wing molt mainly in tropical or subtropical latitudes. Group D: austral migrants; prebasic wing molt mainly in temperate latitudes during n summer.

	A	B	C	D
Sooty Shearwater				X -
Short-tailed Shearwater				X -
Flesh-footed Shearwater				X -
Pink-footed Shearwater				X -
Buller's Shearwater				X -
Wedge-tailed Shearwater			X -	
Great Shearwater				X -
Cory's Shearwater		X -		
Scopoli's Shearwater		X -		
Manx Shearwater		X -		
Townsend's Shearwater			X -	
Black-vented Shearwater			X -	
Galapagos Shearwater			X -	
Christmas Shearwater			X -	
Black-capped Petrel			X -	
Bermuda Petrel			X -	
Desertas/Cape Verde Petrel			X -	
Trinidade Petrel			X -	
Cook's Petrel			X -	
Mottled Petrel				X -
Hawaiian Petrel			X -	
Galapagos Petrel			X -	
Juan Fernandez Petrel			X -	
Kermadec Petrel			X -	
Herald/Henderson Petrel			X -	
Tahiti Petrel			X -	
Northern Fulmar	X -			
Parkinson's Petrel			X -	
Black-footed Albatross	X -			
Laysan Albatross	X -			
Steller's Albatross	X -			
Wilson's Storm-Petrel				X -
Leach's Storm-Petrel		X -		

Table 5. *cont.* Molt strategies of selected petrels, albatrosses, and storm-petrels

	A	B	C	D
Townsend's [Leach's] Storm-Petrel		X		
Grant's [Band-rumped] Storm-Petrel			X	
Darwin's [Band-rumped] Storm-Petrel			X	
Wedge-rumped Storm-Petrel			X	
Black Storm-Petrel		X		
Least Storm-Petrel		X		
Ashy Storm-Petrel	X			
Markham's Storm-Petrel			X	
Fork-tailed Storm-Petrel	X			
White-faced Storm-Petrel			X	

HOW TO SEE TUBENOSES

Seeing tubenoses is as easy as getting on a boat and taking what is known as a pelagic trip, or simply "a pelagic." And some tubenoses can even be seen from shore, although usually not as well as they can from a boat. That said, a few tips may be helpful if you've never been on a pelagic or have tried only one or two. Because you'll be on a moving platform at all times, pelagic birding is some of the most challenging birding there is. As on land there will be slower birding days, and even on great days there will be slower periods. The number of bird species on a pelagic day trip may be only in the order of 12–20 (with perhaps only 4–10 tubenoses), but they'll include some good birds. Given the manageable number of species you can easily review the possibilities beforehand. So when somebody shouts out "Flesh-footed Shearwater" or "Fea's Petrel!" you have an image of what you are looking for and can pick out the right bird, which may simply fly by the boat once and be gone. You can determine which species might be seen by looking at trip reports from pelagics taken in the same area and season in earlier years; reports are usually available on websites maintained by pelagic trip operators. As with birding tours on land, if you're going on a pelagic it's good to pick a reputable company with experienced leaders who can help you see the birds and explain how to identify them. Word of mouth among the birding community is a good way to learn which are the best pelagic operators.

Good waterproof binoculars and a rainguard are important. You don't want to test the waterproofing of your binoculars at sea, but it's better to be prepared. Telescopes and tripods are not practical except on larger vessels (such as big ferries or cruise ships) and mainly in calmer seas. Obviously they're really helpful if you're watching from shore. Good 8-power or 7-power binoculars are better at sea than 10-power; the lower magnifications have a wider, brighter, and deeper field of view and are easier to hold steady—all big advantages on a moving platform while watching moving subjects over a moving surface. That said, a lot of watching from boats is best done with the naked eye, at least until you feel comfortable being on a moving platform. Think about trying to watch birds using binoculars from the back of a pickup truck driving down a dirt road—using your naked eye is a lot easier. However, when the boat stops, or birds are close, then this is the time to use your binoculars to get a good view of things.

Books could be written on the dos and don'ts of pelagic birding, but the best way to learn is to take a few trips. The following is some advice gleaned from years of pelagic trips (and see Howell 2007a). On the boat find a place with a wide field of view, sheltered from any wind buffeting, and not looking into the sun; this is not always possible, but aim for the best combination of these factors. From high up on a larger ship you can see farther and not lose sight of birds behind waves, but it can be difficult to spot birds against the ocean. Being nearer the sea surface it is easier to spot birds as they wheel above the horizon and to discern whether wingbeats are shallow or deep, but it is also easy to lose sight of birds behind waves. If you want help from leaders or more experienced birders stay fairly close to them—words can be hard to hear on a boat, birds often don't stay around long, and leaders tend to stand in the best places to see from.

Polarized sunglasses help greatly in cutting down glare, and sunscreen is a good idea, even on partly cloudy days, because reflection from the sea can be strong. Earplugs can be helpful if the boat has loud engines. Keep a dry cloth or tissues handy in a Ziploc bag for wiping off your lenses, which can be licked first to remove salt and avoid scratching. A cube or two of ice from an ice-chest is good for rinsing your hands and face of saltwater, and also refreshing. After a pelagic it's good to rinse off any salt spray residue with freshwater, to prolong the functional life of your optics.

Seasickness? If you've never been on a boat don't assume you'll get seasick, particularly if you take the following precautions. I think it's better to try a short trip free from drugs, as some seasickness medications can make you queasy, dry mouthed, and sleepy, none of which is likely to enhance your experience. Instead, get a good night's sleep; stay outside with a breeze in your face; watch the horizon; don't read or look down (review species you might see the day before—there aren't that many); and use your binoculars only to look at birds you can see with the naked eye. It's helpful to keep food and water on your person to avoid going into the cabin; eat light meals and keep something in your stomach during the trip. Some people find saltine crackers or ginger cookies are good to munch on; I find grapes and other sharp tastes, like mints, more refreshing. Standing all day at sea can be tiring, and on longer trips you can lie down or sit down and take naps.

One possibility for seeing pelagic species well on land is to follow the paths of tropical storms and seek birds pushed onshore or inland to reservoirs. In the East, hurricanes can carry birds inland as far as the eastern Great Lakes and also up the Mississippi watershed from the Gulf of Mexico. In the West, storms can sweep birds up into the Gulf of California and on to the Salton Sea (where at least eight species of tubenoses have been recorded; Patten et al. 2003) or other water bodies such as Lake Havasu on the Arizona/California border (Jones 1999).

CONSERVATION

Tubenose numbers today are a mere fraction of what they once were—before humans brought non-native mammals (including themselves) to former seabird havens across the planet. Of the 70 or so tubenose species recorded in the region, about one-third qualify as vulnerable or endangered globally due to human activities, past or present (Birdlife International 2010a). We should all be familiar with the decimation of whale stocks worldwide caused by hunting, but the fates of tubenoses have been no less dramatic. Pelagic trips out of California only 150 years ago could have encountered tens or hundreds of Steller's Albatrosses, perhaps even hundreds of Guadalupe Storm-Petrels—we can only imagine. Trips out of North Carolina at that time might have found thousands of Black-capped Petrels, hundreds of Desertas Petrels—and maybe even hundreds of Jamaican Petrels. We can only hope that someone writing 50 or 100 years from now will not be lamenting the loss of Townsend's Shearwater (Fig. 59), or of the great albatrosses, whose populations are in rapid decline. As whaling should be viewed in its historical context, the introduction of non-native mammals to islands was, for the most part, inadvertent. But by now we should have learned.

Fig 59. Townsend's Shearwater may today breed on only one island off Mexico, where it is preyed upon by feral cats. Without prompt action this rapidly declining species may become extinct in our lifetime. On this date, fresh plumage indicates a juvenile—confirmation that at least one pair bred successfully in 2010. MS. Baja California Sur, 20 Aug 2010.

Seabird conservation and study have traditionally focused on the breeding grounds, because birds are easiest to study there. The study of tubenoses at sea, where they spend most of their lives, involves numerous logistical factors that have limited this area of research. But problems at sea are also great, and understanding all aspects of a species' life history is necessary if we are to have any hope of conserving it. Likewise, an understanding of the entire marine environment, not just birds, is critical to maintaining the health of our planet.

Threats to Seabirds

Seabirds such as tubenoses are long-lived and adapted to periodic natural phenomena such as ocean food-web crashes, from which their populations recover over time. But the addition of human-induced mortality when seabird populations are at a naturally low ebb could push some species over the edge. Human-caused threats to seabirds can be divided broadly into competition and contamination. Competition includes the impact of fisheries and the modification of nesting habitats. Contamination includes the effects of oil, plastics, and other chemicals in the ocean, the effects of lights on vessels at night, and the impacts of introduced (non-native) species on nesting grounds.

Fisheries impact birds by overfishing stocks that are a resource shared by humans and seabirds; by causing seabird mortality as incidental catch (or "bycatch") through gill-netting, long-lining, or other fishing activities; and by wholesale marine habitat destruction, such as caused by bottom-trawling for fish, which effectively strip-mines the ocean floor. It has been calculated that around 1500 square km (580 square miles) of deep ocean floor are hit by trawls each day—*for every breath we take, an area covering 10 football pitches is stripped of its fish and invertebrates* (Roberts 2007:340); this short-term greed is not sustainable, its consequences are to the detriment of humans and seabirds alike. On land, seabird nesting sites can be built upon for homes or businesses, or altered for human recreational pursuits. The effects of oil and other chemical spills on seabirds should be well known, and the washing ashore of unsightly oiled birds on recreational beaches has forced this problem into our conservation consciousness. The effects of plastics in the sea are more insidious: small pieces of plastic look much like the food items of many tubenoses and are eaten by mistake. The plastics do not break down in the birds' stomachs but accumulate so that there is no room for food or liquid—and the birds die with a full stomach (Fig 60). At night, many seabirds are attracted to lights much as happens with moths and candles. If brightly lit vessels are anchored near nesting islands, the decks can become littered with birds (Fig 61), many of which become soiled or crawl off and die in corners.

Seabirds tend to nest on or under the ground and they seek predator-free islands on which to nest. Enter humans, with their rats, cats, dogs, mongooses, and other species that prey on adult and nestling seabirds. Thus, millions of seabirds have been killed worldwide and perhaps hundreds of islands made uninhabitable for nesting. Rabbits, goats, sheep, and other species trample nest burrows and modify habitat through overgrazing, which destabilizes soil. And introduced plants can grow up and cover areas with dense vegetation, making them unsuitable for birds that require open ground for nesting. Two tubenose species endemic to the region covered by this guide have become extinct in the past 100 years—the Jamaican Petrel and the Guadalupe Storm-Petrel. Both are apparently gone forever, killed on their nesting grounds by cats and other introduced mammals.

It's not all doom and gloom, though. With increased awareness and education, in tandem with regulation and restoration, seabird population declines are slowing and some species may even be increasing. The concept of marine reserves and protected areas, where fish stocks have a chance to recover and ecosystems can regenerate, is slowly catching on—but whereas about 12% of the Earth's land area is contained in protected areas, the corresponding figure for the sea is only about 0.6% (Roberts 2007:374). Fishermen don't want seabirds on hooks that could catch fish, and many are adopting techniques that reduce or eliminate seabird bycatch. The *Save the Albatross* campaign (www.savethealbatross.net) has been prominent in highlighting this worldwide issue. On islands where tubenoses and other seabirds nest, conservation groups (such as Island Conservation, www.islandconservation.org, and its sister organization Conservación de Islas) are working to eliminate non-native animals and plants so that seabird populations have a chance to recover or recolonize. Seabird and marine conservation awareness has come a long way in the past 50 years, but it still has a much longer way to go.

Seabirds as Indicators

Humans have relatively coarse-grain environmental filters, particularly with respect to the ocean; we are, after all, ostensibly terrestrial mammals. Our attempts to understand marine processes rely on a limited number of variables that we can measure, and as far as oceanography goes we're little more than dilettantes, albeit technologically sophisticated ones. Seabirds, on the other hand, are professionals—they feed and breed in the oceanic environment for a living, and if they fail, they die. If enough of them die it could be a sign that humans will soon follow along the road to extinction.

Monitoring seabird population trends can give us an index of marine ecosystem health, and seabird populations are easier to see and to study than fish and other organisms that lie below the inscrutable ocean surface. A fundamental first step in studying any organism is the ability to identify and name it. Hopefully this guide will aid in the identification, appreciation, monitoring, and conservation of tubenoses.

Fig 60. Plastics and other trash in the ocean can be mistaken for prey by albatrosses and fed to their young, whose stomachs become so full of plastics (which cannot be digested and passed through the system) that there is no room for real food. Thus, many juvenile Laysan and Black-footed albatrosses starve to death with a full stomach. After their bodies rot away, all that remains is a pile of bottle tops, fishing lures, and other agents of death. RdG. Midway Atoll, Hawaii, 3 Jan 2007.

Fig 61. Like moths drawn to a candle, seabirds (such as these Fork-tailed Storm-Petrels) are attracted to lights on ships, perhaps a form of night-blindness, and seem unable to leave the ring of light surrounding a vessel. Many cannot take off again or crawl into oily nooks and crannies where they starve to death. Untold thousands of seabirds probably die each year in this way (in this instance the birds were safely removed and released). KL. Off Aleutian Islands, Alaska, 1 Aug 2003.