Overflight Monitoring in the West Coast National Marine Sanctuaries

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Executive Summary

This report provides an overview of overflights in the West Coast National Marine Sanctuaries, including the Olympic Coast National Marine Sanctuary (OCNMS) in Washington, and the Gulf of the Farallones National Marine Sanctuary (GFNMS), Monterey Bay National Sanctuary (MBNMS) and Channel Islands National Marine Sanctuary (CINMS) in California. All of these Sanctuaries have regulations restricting aircraft flights over Sanctuary waters. However, these regulations have been difficult to enforce or even communicate to relevant constituents. In fact, the extent of overflights within the Sanctuaries including the number and altitude of aircraft is not known. It is also unclear whether, or how much, disturbance to Sanctuary-protected wildlife results from overflights. This report was commissioned to examine potential solutions for monitoring overflights and associated wildlife disturbance within the four West Coast Sanctuaries.

An overflight is broadly defined in this report as an aircraft (whether helicopter, plane, or other type of aircraft) that flies over Sanctuary waters. We are primarily concerned with low overflights, especially those that occur under the legal limit for the Sanctuaries (2000 feet in OCNMS, or 1000 feet in GFNMS, MBNMS, and CINMS) and have the potential to cause wildlife disturbance. In this report we focus primarily on small private general aviation aircraft, typically flying under visual flight rules (VFR). These aircraft are generally flown by private pilots for sightseeing purposes and have the potential to fly extremely low over Sanctuary waters. Other types of aircraft that are present in the Sanctuaries to a lesser extent are regularly scheduled tourist flights, such as those provided by National Park tour concessionaires, and Sanctuary-permitted or Sanctuary-owned research flights. Military and Coast Guard flights also occur over all Sanctuaries.

Previous studies of overflights have typically used a combination of human observers and acoustic monitoring in order to measure noise levels of overflights and determine frequency and severity of wildlife disturbance. Most authors conclude that overflights do cause wildlife disturbance, but effects vary with plane type, elevation, and wildlife species. Studies on Bald Eagles and bowhead and beluga whales founds that helicopters typically cause more disturbance (Grubb and Bowerman 1997, Patenaude et al. 2002). Closer aircraft were also linked to more disturbance (Grubb and Bowerman 1997, Patenaude 2002, Stalmaster and Kaiser 1997, USFWS 2000). However, studies have also shown that response varies by species and even related species, such as black and wood ducks, respond differently (Conomy et al. 1998b).

For overflight monitoring purposes, we present a series of recommendations relevant to different goals: (1) determining frequency of overflights over the Sanctuaries, (2) determining associated wildlife disturbance, and (3) pursuing enforcement action. Determining overall goals (within and among Sanctuaries) will determine what kind of monitoring program to implement. Five possible technological monitoring solutions were examined:

- **Transponder scanner**—a device that intercepts transponder signals from aircraft in the vicinity providing altitude and relative location information for planes equip with a transponder that is interrogated by radar or a commercial aircraft. Transponder scanners are relatively inexpensive and can detect planes during conditions when human observers would be unreliable.
- **RADAR**—detects objects and measures their range according to how they scatter or reflect radio energy. Portable radar is a proven technology for tracking objects in the sky and can detect altitude accurately, but is relatively expensive and has high power requirements.

- **Acoustic monitoring**—uses audio recording equipment to measure and record background noise and noise "events." Acoustic monitoring in relatively inexpensive, but may be difficult to implement in a noisy environment such as the coast and cannot identify aircraft altitude.
- **Telepresence**—uses a camera system to remotely monitor something, such as wildlife. While telepresence is not practical for monitoring aircraft, it is a proven technology for monitoring wildlife disturbance.
- **Airport and FAA data**—radar information currently collected by airports and the FAA on aircraft location and altitude within radar coverage areas. These data are only available for specific small areas within the West Coast Sanctuaries since not all areas are in close proximity to airports or within FAA radar coverage.

All technologies are limited in not being able to uniquely identify individual aircraft or provide quantitative data on numbers of overflights under all conditions. As an alternative, a human observation program is outlined. At a minimum, we recommend that human observers record: date, time, location of observer, name of observer, type of aircraft, flight path of aircraft, and species-specific standardized response. Finally, potential combinations of technological systems and human monitoring are described relative to monitoring goals:

- **Frequency and altitude**—transponder scanner system and human observation program
- **Wildlife disturbance**—human observation program (with acoustic monitoring if data on noise thresholds and desired, and telepresence if remote viewing of wildlife is necessary)
- **Enforcement (altitude only)**—human observation program and portable radar
- **Enforcement (altitude and disturbance)**—human observation program and portable radar (with telepresence if remote viewing of wildlife is necessary)

In addition, we discuss outreach and education to pilots, and inter-Sanctuary and inter-agency coordination, including the development of a West Coast Sanctuary Overflight Working Group. Education and outreach to pilots should be conducted through pilot groups, airshows, flight training schools, and airports in the vicinity of the Sanctuaries, preferably by contracting with individuals with immediate recognition and statue in the aviation community. Education and outreach messages should be standardized across Sanctuaries and should include the safety concerns of low overflights. Efforts should continue for official FAA recognition of Sanctuary regulations, as this will ultimately be the strongest message to pilots. Coordination should also continue with the military and coast guard and national parks and national wildlife refuges to standardize messages and reduce occurrence of low overflights.

As a next step, we recommend a pilot monitoring study combining transponder scanners and the development and testing of a human observer program. Concurrently, we recommend the establishment of an overflight working group and development of print and presentation outreach materials. Finally, we recommend ongoing interaction with the FAA to clearly establish Sanctuary regulations on pilot charts.

Sanctuary Overview

OCNMS, GFNMS, MBNMS, and CINMS together include almost 9,000 square nautical miles of the marine environment off the West Coast. Collectively, the West Coast Sanctuaries are home to hundreds of species of marine birds, dozens of marine mammals, and many fish and invertebrates. Wildlife in the Sanctuaries are potentially at risk from disturbance from low flying aircraft. With respect to the possibility of overflight occurrence, MBNMS and GFNMS are located near large urban areas, CINMS has airports on the islands located within the Sanctuary, and OCNMS is geographically remote.

Regulations regarding overflights vary between Sanctuaries. CINMS and GFNMS both prohibit disturbing seabirds or marine mammals by flying motorized aircraft at less than 1000 feet within one nautical mile of any island. MBNMS prohibits flying motorized aircraft under 1000 feet within four areas of the Sanctuary. All three California Sanctuaries have exceptions to this rule for the purposes of valid law enforcement purposes, and CINMS and GFNMS allow exceptions for transporting people and supplies to or from an Island. OCNMS prohibits flying motorized aircraft at less than 2,000 feet within one nautical mile of islands within the Sanctuary as well as within one nautical mile of the coastal boundary of the Sanctuary, with exceptions for tribal activities. For specific text of the regulations for each Sanctuary, please refer to Appendix A. Although a part of federal law, National Marine Sanctuary overflight regulations are not recognized by the Federal Aviation Administration (FAA).

Sanctuary concerns and summary of interview process

We conducted 18 interviews of Sanctuary personnel from the four West Coast National Marine Sanctuaries considered in this study. In addition, we interviewed two National Park employees (Channel Islands National Park, Olympic National Park) and many technology experts. Interviews of Sanctuary and Park employees were conducted to get an overview of current overflight conditions in each of the Sanctuary areas, including frequency of occurrence, incidence of disturbance, primary species at risk from disturbance, current regulations, monitoring and enforcement, and possibilities for technological or personnel-based monitoring systems. Interview questions were designed with assistance from George Galasso, OCNMS and are listed in Appendix B. Interviews were recorded with permission from all parties, and summaries were compiled for each Sanctuary (see Appendix C). Interviews of technology experts were conducted to compile information on technology specifications and applicability to overflight monitoring.

We asked Sanctuary personnel about their perceptions of overflight frequency and whether there have been any complaints by members of the public or public organizations (for instance, environmental organizations) about overflights within the Sanctuaries. Not surprisingly, perceptions of overflights varied among Sanctuaries. OCNMS personnel reported that overflights occur primarily during the summer and that complaints are rare. At GFNMS, on the other hand, personnel reported persistent noise in the summer from overflights, and noted that they have received complaints. The situation is much the same in MBNMS, with personnel reporting overflights as common, with frequent violations of the Sanctuary floor, and numerous complaints from environmental organizations and the general public. Finally, CINMS personnel reported low overflight frequency, with few-to-no complaints. One comment common to most interviews was that the most frequently perceived sources of wildlife disturbance within the Sanctuaries are from watercraft, including motorized vessels, jet skis, and kayakers. However, all agreed that the intensity of disturbance can be much greater from a single overflight incident.

In general, overflight and wildlife disturbance monitoring efforts in the Sanctuaries have been largely opportunistic. However, all of the Sanctuaries have existing personnel and permitted researchers present in the Sanctuary during at least part of the year, and these experts could be tapped for a more standardized human observer program. GFNMS conducted a study on wildlife disturbance in response to known overflights resulting in unpublished data (J. Roletto, pers comm.) There are also unpublished data from Tatoosh Island in OCNMS. From the initial interviews and subsequent conversations with sanctuary personnel, there appears to be a wealth of opportunistic and anecdotal information with respect to overflights and wildlife response. These data could be compiled into a more comprehensive report of overflight incidence.

Literature Review

The overflight problem – background legal history

In addition to the National Marine Sanctuaries, overflights have historically have been a concern in the National Park system and within urban and residential communities near airports. In both settings, there has been concern over aircraft noise disturbing humans (Miller 1999). There are currently overflight regulations in several of the National Parks. However, there has also been controversy over regulating overflights, particularly in Parks such as the Grand Canyon where air tours are popular (Eisenger et al. 1989). These debates have centered around the issue of preserving natural quiet for visitors, and have focused on commercial air tour companies rather than on private pilots (although Voorhees and Krey (1999) conclude that, in fact, military and private general aviation overflights are the most problematic in the Parks). Public Law 100-91, passed in 1987, called for the Secretary of the Interior to report back to Congress "regarding actions necessary for the protection of resources in the Grand Canyon" and to present a report on overflight noise disturbance in the Parks. After being sued by community and environmental groups, the National Park Service (NPS) finally delivered this report in 1995. The report focused on the effects of overflights in the National Parks and included a bibliography of material on wildlife disturbance (NPS 1995, Stokes et al 1999). Recommendations to Congress in the report included improving and managing agency processes for resolving conflicts and for collaboration between the NPS and the FAA, the Department of Defense, and other agencies to develop rules regulating overflights. The NPS also recommended using a wide range of tools to manage overflights, including voluntary agreements, incentives for quieter aircraft, spatial zoning, altitude restrictions, and regulating air tour operators (NPS 1995).

Progress on developing rules on overflights in the National Parks was slow, and legislative debate continued through the mid-1990s, with the introduction of several bills designed to regulate or prevent overflights in individual Parks. The National Parks Overflight Working Group (NPOWG), an inter-agency working group between commercial air tour groups, the Parks and the FAA met in 1997 to make recommendations on overflight regulations over the Parks. Based on their recommendations, the National Parks Air Tour Management Act passed in 2000, which regulated air tour overflights over the Parks ("Notice of Establishment of a Joint NPOWG" 1997). The FAA did not codify rules relating to this legislation until 2002, when they stated that air tour companies had to apply for permits to fly below a 5000-foot ceiling, and that Parks where air tours occurred must develop air tour management plans. These existing rules, particularly in the Grand Canyon, are contentious and under review by the FAA and NPS.

With respect to wildlife disturbance, a more general federal law is the Airborne Hunting Act of 1972, which prohibits shooting, attempting to shoot, or harassing any bird, fish, or other animal from aircraft unless operating under a state or federal permit to administer or protect wildlife, livestock, land, water, crops or human life. At least one case involving coastal resources has been prosecuted under this law – that of James Cheatham, a helicopter pilot who was charged in February 2005 with a misdemeanor count of airborne harassment of birds and ordered to keep his helicopter at least 2,500 feet away from common murres at the Castle Rock Murre Colony in Monterey County, California (Lee 2003, Nix 2003, Lee 2005).

Overflight regulations in the National Marine Sanctuaries, unlike those in the National Parks, are not system-wide and although a part of Federal law are not recognized by the FAA. Although the FAA does not recognize Sanctuary flight restrictions, visual flight rule (VFR) pilot navigation charts indicate GFNMS, MBNMS and CINMS (but not OCNMS) restricted areas as: "pilots are requested to maintain a minimum altitude of 2000' AGL." This altitude is in accordance with FAA guidelines for National Parks and National Wildlife Refuges. These Parks and Refuges are also marked on VFR charts for the West Coast, with a note that "All aircraft are requested to maintain a minimum altitude of 2,000 feet above the surface of the following: National Parks, Monuments, Seashores, Lakeshores, Recreation Areas, and Scenic Riverways administered by the U.S. Fish and Wildlife Service; and Wilderness and Primitive areas administered by the U.S. Forest Service." Additionally, the Seattle VFR chart, which covers the outer coast of Washington and Oregon, includes a box that states: "Notice to pilots: The Islands, Rocks and Reefs along the Pacific Coast-Line from 42,00'N to 46,00'N are National Wildlife Refuges. Low flights may disturb wildlife resulting in a violation of Federal law." All pilots are legally required to familiarize themselves with posted regulations on the appropriate charts and follow them.

General FAA airspace regulations for areas not covered under other exceptions state that a person flying under VFR rules must stay above 1,000 feet above the surface over land for day operations, or 500 feet from any obstacle if over water (14CFR91.119, 14CFR91.515).

Studies that detect and monitor overflights – methods and proven technologies

Proven technologies for monitoring overflights include acoustical monitoring of aircraft noise and visual observation of overflights. However, there have been few systematic studies attempting to quantify overflights over protected areas. In response to overflight legislation, the National Park system contracted to interview park managers, review secondary sources, and acoustically monitor background sound levels to determine the extent of the overflight problem in the National Parks (National Park Service 1995). As part of this report, sound levels were monitored as "percent of time audible," a metric in which observers recorded the total time they could hear aircraft at a particular site as a percentage of the total time observed. This report did not attempt to quantify numbers of overflights or directly measure overflight noise over the Parks, concluding that "there is no accurate method for estimating the level of general aviation traffic on any route within any airspace" (NPS 1995).

The methods used for acoustic monitoring of aircraft overflight noise in the National Parks are described by Dunholter et al. (1989) in a report that also includes background information on sound characteristics and a literature review of aircraft noise assessment techniques. This report concluded that there are several factors affecting the perception of aircraft noise, including: background sound levels, aircraft sound level (relative to background and absolute levels), spectral characteristics of the sound, duration of the aircraft sound, and onset rate of the aircraft sound. Dunholter et al. (1989) used DAT recorders set to continuously record sound levels to tape for later analysis. The data were analyzed to determine the sound parameters described above. A related but simplified acoustic monitoring method for the National Parks is described by Miller et al. (1995). An observer records sound levels at regular time intervals, noting the cause of noise, whether aircraft overflight or something else. This method is very similar to one described by Hamilton (2003) at the Great Barrier Reef Marine Park (GBRMP) in Australia, that used sound monitors and human observers to record noise episodes. In general, acoustic methods provide data on sound levels of overflights, but not the altitude of overflights or associated wildlife disturbance.

The Institute for Environmental Monitoring and Review (IEMR) is an ongoing program sponsored by the Canadian government, charged with overseeing "the environmental effects of allied flight training conducted at the Canadian Forces Base at Goose Bay over areas of Labrador and Northeastern Québec" (IEMR 2005). IEMR studies the effects of low military overflights on wildlife; and has implemented and tested mitigation strategies, including reconfiguring flight areas and limiting overflights to certain areas. Monitoring methods include observing wildlife response to overflight noise while simultaneously monitoring sound levels with a digital sound-level meter (Trimper et al. 1998a and 1998b).

A proposed framework for estimating the level and effects of overflights, focusing on environmental risk assessment and impact analysis of military overflights, was developed by Efroymson et al. (2001) and Efroymson and Suter (2001). Efroymson and Suter (2001) focus particularly on estimating effects on wildlife. These two papers outline a conceptual model of overflight stressors and enumerate criteria to be considered when conducting an ecological risk assessment of overflight activities, including properties of wildlife, properties of the environment (such as local geology and wind conditions), properties of aircraft, and characterization of sound exposure. They also describe potential wildlife behavioral responses and estimate distance thresholds for various species using information in the literature.

It is worth noting that most of these studies have focused on only one type of aircraft, such as military jets or civilian planes, each of which tend to pose different problems. For instance, military jets are loud and often quite low but operate within defined airspace, whereas private general aviation planes may vary dramatically in how loud they are and where they operate (Dunholter 1989).

Human observer programs to monitor aircraft overflights, such as citizen science programs, have been limited. The primary estimations of overflight frequency within National Parks have been made by park managers who kept informal counts of overflights over their jurisdiction (Voorhees and Krey 1999). There is a small amount of data opportunistically collected on overflights within OCNMS, specifically from observers on Tatoosh Island, who keep a tally of aircraft type and estimated altitude, while making observations on nesting common murres (Galasso 2005). Data collected on Tatoosh include date; time; location of observer; weather; location, path, estimated altitude, and description of aircraft, including tail numbers when possible; and wildlife response when possible. GFNMS observed known overflights to determine possible associated wildlife disturbance. Data collected included specific aircraft used; duration and estimated altitude of aircraft; and counts of wildlife present and response to overflight (Rolleto pers. comm., unpublished data). Guidance for developing a volunteer observation program may be drawn from other citizen science programs already in existence on the West Coast, such as the beach monitoring surveys COASST (WA), BeachWatchers (CA) and BeachCOMBERS (CA).

Studies that document effects of overflights on wildlife

There has been a great deal written about aircraft disturbance of wildlife, including a number of literature reviews of the subject. The literature on noise (more broadly defined than aircraft disturbance) disturbance of marine mammals is reviewed by Myrberg (1990). Manci et al. (1988) synthesized the literature on noise and wildlife disturbance, focusing on military overflights and sonic booms. Gladwin et al. (1988) and McKechnie and Gladwin (1993) reviewed the literature on noise and aircraft disturbance effects on wildlife, including avian and marine species. National Park Service (1995) also summarized the literature on aircraft disturbance to wildlife as part of their report to Congress, including a table of species and observed effects. A review of aircraft disturbance to wildlife, including seabirds and marine mammals specifically found in the West Coast Sanctuaries, was completed by Moore (1997). Discussion and description of all of these reviews and the literature on which they are based is outside the scope of this report. Here we will highlight those studies focusing on species relevant to the Sanctuaries published since the 1997 Moore literature review.

Most recent studies involved observing wildlife during overflight events. Overflights were opportunistic (Grubb and Bowerman 1997, Trimper et al. 1998a), conducted by the researcher (Ward et al. 1999, Stalmaster and Kaiser 1997, Trimper et al. 1998b), commissioned by the researcher (Palmer et al. 2003) or simulated (Brown 1990, Conomy 1998b). Some studies also measured noise levels as well, in an attempt to correlate noise levels with wildlife response (Brown 1990, Conomy et al. 1998a, Giese and Riddle 1999, Trimper et al. 1998b). All of these studies relied on audio equipment to measure noise levels of aircraft, while simultaneously quantifying the short-term responses of wildlife with direct observation. Finally, Palmer et al. (2003) measured aircraft noise exposure of Peregrine falcon nests and then monitored subsequent attendance behavior.

Many recent studies of the effects of overflights have found that low-flying aircraft disturb many avian species, with behavioral reactions ranging from becoming more vigilant and alert, including scanning by head-turning, to flushing (Brown 1990, Giese and Riddle 1999, Stalmaster and Kaiser 1997, Ward et al. 1999). However, disturbance varies by species and the specifics of the situation such that even related species (e.g. black and wood ducks) differ in their responses (black and wood ducks - Conomy et al. 1998b, brant and Canada geese - Ward et al. 1999). Disturbance may also not occur or be minimal. At least one study (Peregrine falcons – Palmer 2003) found no apparent change in parental behavior from low (<150m) military overflights, while another study (black ducks, American wigeon, gadwall, green-winged teal – Conomy et al. 1998b) found minimal disturbance caused by military overflights. In their review of overflight and wildlife disturbance (1995), NPS also indicated mixed results, with some species exhibiting response to overflights but other species showing minimal or no response (NPS 1995). There are few studies that have documented the response of marine mammals to overflights. Studies measuring the response of marine animals to noise are summarized by Myrberg (1990), who notes numerous reports of marine mammal disturbance caused by man-made sources, including off-shore oil drilling and shipping. Patenaude et al. (2002) found that beluga and bowhead whales did react to both helicopter and fixed-wing aircraft overflights. In general, conclusions based on responses of one species are not necessarily transferable to another species, as is also the case within species among aircraft types (Manci et al. 1988, NPS 1995).

Response to aircraft may depend on overflight frequency. With increasing numbers of overflights, some wildlife may habituate to aircraft noise (black ducks – Conomy et al. 1998b) whereas other species do not (wood ducks – Conomy et al. 1998b, brant, emperor, and Canada geese - Ward and Stehn 1989). Sensitization may also occur; the response of harbor seals increased with greater overflight occurrence (Johnson 1977 in Moore 1997).

The level of disturbance varies depending on the type of aircraft, with helicopters typically causing more disturbance (breeding Bald eagles - Grubb and Bowerman 1997, bowhead and beluga whales - Patenaude et. al. 2002). In a study of nesting osprey, Trimper et al. (1998b) found that adult osprey did not appear to be disturbed by military overflights at various distances, 1.39 km from the nest, but reacted strongly to float planes approaching within 3 km.
The proximity of aircraft to wildlife also plays a role in affecting response, with closer aircraft linked to more disturbance (breeding Bald Eagles - Grubb and Bowerman 1997, bowhead and

beluga whales – Patenaude 2002, wintering Bald Eagles - Stalmaster and Kaiser 1997, USFWS 2000). Based on a literature review, USFWS (2000) conclude that "an inverse relationship exists between the distance from the helicopter to the subject and the rate of response." The lateral distance of the aircraft also strongly affects whether wildlife are disturbed; in a study of Brant and Canada geese, lateral distance was the strongest determinant of whether Brant geese were disturbed (Ward et al. 1999).

Both aircraft noise and the visual effect of appearing aircraft may be factors in wildlife disturbance. The correlation between distance and increased disturbance may be because of increasing noise levels. In a field study using playback of recordings of overflights to measure effects on seabirds, Brown (1990) found that level of response increases with increasing noise. This is notable because not all aircraft produce the same amount of noise; thus a quieter, closer aircraft may cause less disturbance than a noisier aircraft farther away. However, although most studies focused on noise, the sudden appearance of aircraft, especially in the case of infrequent overflights, may also disturb wildlife, a conclusion hypothesized by Brown (1990) and reached by Trimper et al. (1998a).

Based on observed disturbance caused by overflights, several authors conclude that aircraft altitude restrictions should be developed or maintained, with recommendations for the distance aircraft should stay from wildlife ranging from 500 to 5000 feet, depending on the species under consideration. Aircraft regulations are particularly recommended around foraging areas, for breeding species, and for young (Giese and Riddle 1999, Grubb and Bowerman 1997, Stalmaster and Kaiser 1997). Finally, based on a review of studies of response of species found in the West Coast Sanctuaries, Moore (1997) concludes that overflights "can and do disturb wildlife," and that overflight restrictions over the Sanctuaries should be maintained.

Technology options

Based on interviews with Sanctuary personnel and technology experts, and existing literature, we explored five technological solutions for potential use in overflight monitoring: 1) a transponder monitoring system, 2) portable radar, 3) acoustic monitoring, 4) telepresence, and 5) use of existing airport and FAA radar data. A table comparing all of these options is provided in Appendix D. Several of these technologies may be used in combination with each other, and they could all be used in combination with a human observation program. The major advantage of technology-based systems is that they may be able to provide accurate information on the presence and often altitude of planes flying over the Sanctuaries on a continuous basis, including during conditions where human observers may be unreliable or unavailable, such as at night or in bad weather. Vendor information for specific technological solutions is provided in Appendix E.

Although each of the technological options examined can be used to determine the presence and in some cases the altitude of planes flying over the Sanctuary, none of them are able to provide positive identification of individual planes, as would be necessary for enforcement. This is because small general aviation planes, such as those the Sanctuaries are most concerned with, fly under visual (VFR) rules and are not required to file a flight plan or carry a transponder. The only way to conclusively identify them is by tail number, which must be visually observed. Finally, with the exception of telepresence, all of these technologies must be used in combination with human observers to provide data on wildlife disturbance during an overflight event.

Transponder scanning system

Pros

- Relatively inexpensive – \$800 ea. for most expensive unit found
- Small and low power consumption
- Can scan the entire sky
- Can detect altitude accurately
- Can detect planes during conditions when human observers are unreliable (e.g., at night)

Cons

- Depends on radar or large jets being present to trigger transponders
- Planes without transponders will not be detected
- Data output requires some programming to be interpreted
- Cannot identify individual planes

Transponder scanners are devices that are designed to be mounted inside airplanes in order to detect other air traffic in the vicinity. However, transponder scanners can also be used from the ground to measure the altitude of aircraft passing overhead, making them potentially useful for an overflight monitoring system. This device is different from a transponder, which is a required device for aircraft in some airspace in order to communicate with the FAA. A transponder sends and receives signals from FAA interrogation systems for the purposes of air traffic control. Transponder scanners, which are an optional added device for pilots, intercept these signals that are sent back and forth in order to determine the location of those aircraft with transponders. On the ground, a transponder scanner would intercept transponder signals sent back and forth from aircraft in the sky and calculate the altitude and range of those aircraft in relation to the scanner (i.e., to the ground). Transponder scanners are passive – they do not actively send information themselves, rather simply intercepting signals that are going by in order to produce a picture of current air traffic in the sky.

Transponder scanners detect in a 360 degree angle, so a unit on the ground would scan the entire sky, or a half-hemisphere. Surecheck's system can scan up to five miles; under two miles the units are accurate to 1/10th of a mile (Clemens, pers. comm.). The data that transponder scanners output consists of numbers representing the range between you and the nearest transponder-equipped airplane and the altitude of that plane. The range that the transponder scanner detects can be set. There is no off-the-shelf data output analysis program or device, as the device data is designed to be read visually by a pilot. However, the data can be stored, and for the Surecheck model of transponder scanner, time-stamped data codes representing planes and their altitudes can be output to a laptop via an adapter cable to a 9-pin serial port to the hyperterm program in Windows. A program could be written which would then interpret this data, producing a list of overflights, their altitudes, and time of occurrence (Hovey and Clemens 2004). By plotting time-stamped data, travel direction of planes can be determined. The transponder scanner is quite small, weighing only a few ounces, and runs on 4 AA batteries or a power adapter (Clemens and Hovey 2004). The entire setup would also need waterproof housing.

A major drawback, however, is that for this system to detect aircraft two parts must exist – the planes that are tracked must have transponders on board and turned on, and there either needs to be an FAA radar installation or large jet aircraft with active transponders present in order to send querying signals and trigger the whole system. This means that all planes may not be tracked. Transponders are not required in general aircraft planes, and planes may (and often do) turn transponders off in airspace where they are not required, which includes most open airspace not near a major airport. Particularly in more populated areas or close to major airports, planes may have transponders for their own safety, but an accurate estimate of the numbers of general aviation planes flying with transponders does not exist (Cox, pers. comm., Gardner, pers. comm.., Kruth, pers. comm.). This is problematic for this method, as without an accurate count of how many general aviation planes have a transponder on board, no accurate or statistically defensible count of how many aircraft are actually present in the sky can be made using only transponder data. Furthermore, radar coverage may not be available in all areas to trigger an aircraft's transponders. Additionally, transponders cannot uniquely identify individual planes, only the altitude of aircraft and if that aircraft uses the "general aviation" transponder code.

Sample system:
Vendor: SureCheck Aviation
System name and number: TrafficScope VRX
Range: 6.0 NM, altimeter accuracy ± 200 feet
Data type: ASCII; would need to write program to interpret and analyze data
Data communication: proprietary port with adaptor cable supplied to output to 9-pin serial port
Data storage: output to laptop
Weatherproofing: not weatherproofed
Additional equipment: waterproof housing and laptop to download data
Power: 4AA batteries (lasts ~7 hrs) or plug in (12v)
Size: 6"x4", 13.25 oz. with batteries
Price: $795.00 plus batteries, weatherproof housing, and laptop (does not include transportation, installation or operation)

Physical environment requirements: Transponder scanners will work in areas where FAA radar coverage exists or commercial aircraft are present. As radar coverage over the Sanctuaries is haphazard, these should be determined by testing the devices in conjunction with human observers.

Radar observation

Pros

- Proven technology for tracking objects in the sky
- Long range scanning ability
- Performs well in fog/nighttime conditions
- Can measure altitude and direction of travel of plane

Cons

- Expensive – price estimates vary but do not go below $8000 for a new unit
- Requires trained operator for installation, data collection and analysis
- Sites must be relatively unobstructed
- Data output options are limited
- "Clutter" of data may be a problem
- High power requirements
- Cannot identify individual planes

RADAR, or RAdio Detection And Ranging, is used to detect objects and measure their range according to how they scatter or reflect radio energy. Radar is commonly used in air and sea applications, including by the FAA, at airports, and by the Coast Guard for tracking ships, as well as by the military. Radar is also sometimes used by scientists for tracking purposes, such as for tracking nocturnal birds (Burger 1997, Burger 2002, Cooper 1991); these projects all used small marine radar units. There are different types and sizes of radar designed for different applications – for instance, without modification marine radars are not designed to scan the sky vertically like an airport terminal radar or an FAA radar system (Cooper, pers. comm.). Radar systems vary in their range, power output, and horizontal and vertical beamwidth.

Radar's use for an overflight monitoring system would be to track aircraft flying over a particular location. A small, stand-alone radar system, such as those used by ornithological researchers, is best for ease of transportation and lessened power consumption. Two possibilities are either a truck-mounted system or a smaller stand-alone marine system such as those designed to go on boats. To use a larger, surveillance radar, it may be beneficial to cooperate with a military site (such as the Navel Postgraduate School in Monterey, which operates a truck-mounted radar system) which may be able to loan equipment and expertise. Radar systems typically consist of the radar unit itself and then a viewing monitor and accessory recording equipment, such as a VCR, as well as a power source such as deep-cycle batteries.

Additionally, modification of off-the-shelf marine radar systems may be necessary to track overflights. Cooper et al. (1991) give directions for modifying Furuno marine radar systems by replacing the waveguide with a parabolic dish and operating the system in a vertical mode in order to measure the altitude of tracked objects. This vertical radar only detects flight altitude and possibly relative direction (i.e., whether the aircraft is flying left to right through the radar beam), but this radar then be combined with another marine radar set to surveillance mode, which measures flight direction, speed and location (Cooper, pers. comm.). Another technique for modifying marine radar to determine the altitude of objects overhead is described by Harmata et al. (1999), who modified the plane of rotation of a standard scanning radar from horizontal to vertical. Finally, Harper et al. (2004) describe another radar system for monitoring marbled murrelets, also using Furuno marine radar systems with the radar scanner's waveguide tilted upward to scan a wider arc (25°).

The downsides of radar systems include their size – they are generally large (weighing around ~200 lb. for the systems described above) and their high power requirements. The researchers that we talked to estimated approximately eight hours of operation for a single small marine radar system on two 12v deep cycle batteries; this estimation depends on the size and power output of the radar system. Cooper et al. (1991) ran two marine radar systems off of four 6-volt golf cart batteries for approximately 14 hours. Other power solutions, such as a generator, would need to be put into place for longer operation times (Cooper, pers. comm.).

The data output of radar is visual (plane tracks or 'blips' on the radar screen). The screen can either be observed in real time by a researcher or a radar system can be connected to a video recorder to record the data output for later review (Bertram et al. 1999). This means that data analysis either requires a human operator on site or offsite reviewing video to determine what radar events are overflights. Interpreting data also requires operator training, since there is a possibility for data "clutter" from birds, aircraft outside the desired ceiling, etc. Radar may also be cluttered by heavy rain or waves, and will not perform well in a hilly or treed site or a site with other terrain obstacles. Coastal sites may thus be good for data collection.

While radar can detect aircraft whether they are equipped with a transponder or not, and can perform in conditions where human observers are unreliable, radar data still requires interpretation to identify a plane. Again, unique identification of aircraft is not possible, only that a plane exists.

Sample system
Vendor: Furuno
System name and number: FR8111 –10 kW x-band radar, output to 12" mono CRT display (x2 to acquire altitude data – see above)
[note: a smaller radar, such as the 1953C NavNet which retails for $7,820.00, may also work well; the studies cited above used various sizes of radars]
Range: 72 nautical miles
Data type: visual onscreen data
Data communication: can be videotaped or exported to a plotter
Data storage: if videotaped with a VCR
Weatherproofing: radar units are designed to be weatherproof; monitor and VCR need weatherproof housing
Additional equipment: Antenna: 6 foot open array Furuno antenna is $1,870.00; weatherproof housing for monitor and recording system.
Power: 8-10 hours on 12v deep-cycle batteries x2 – between $50-$100 ea.
Size: 189 lbs plus antenna and batteries
Price: $12,125.00 for radar plus antenna, batteries = ~$14,195 base cost ea., or $28,390 for two radars (does not include transportation, installation or operation)

Physical environment requirements: RADAR requires an unobstructed site (not heavily treed or in a valley); coastal sites may work well. RADAR sites also either require easy access to change battery systems on a regular basis or a powered site.

Acoustic monitoring

Pros • Inexpensive and fairly easy to get readings • Tested protocols and standards exist for noise measurements • Measuring noise may be an integral part of an accurate disturbance study Cons • Cannot identify the altitude of aircraft • Cannot identify individual planes • May be difficult to get clean data because of other noise events • May be difficult to implement in a noisy environment such as the coast • Cannot guarantee that any individual event is a plane without human observers to correlate visually

Acoustic monitoring involves using technologies to measure background sound levels and the spikes associated with overflights or other noise events. Noise monitoring produces acoustic data, which can be recorded for later analysis. This has been the primary method used in National Parks, as well as in other studies, as a way of monitoring overflights (Dunholter et al. 1989, Fidell 1988, ANSI 1992). This is primarily because preserving natural quiet was cited as a key concern by national park managers in 1980s-1990s surveys (National Park Service 1995, Voorhees and Krey 1999, Ambrose and Burson 2004). Because noise can be a key factor in wildlife disturbance, measuring noise levels may also be a method to study disturbance. However, the altitude of a plane, the noise it produces, and the disturbance that it causes are not necessarily correlated – i.e., a new small plane at 900 feet might be very quiet, while a helicopter or military bomber at a greater height might be much noisier (Gardner, pers. comm.).

Acoustic data can be recorded in either analog or digital formats. There are established protocols for measuring both background noise and noise events, as described in ANSI (1992), Dunholter et al. (1989), Fidell et al. (1988) and Miller et al. (1995). Dunholter et al.'s method included two systems, one designed for frequency analysis and one for continuous measurements. The system for frequency analysis consisted of sound level meters which were input to instrument tape recorders. Continuous measurements of sound levels were acquired with an automated digital noise data acquisition system; these data were primarily used for verification of the taped data, which were analyzed in the laboratory with a dynamic signal analyzer. Both systems were equipped with microphones. A field engineer was present to record weather data, aircraft overflight information, and to stop and start the tape when an aircraft became audible. The goal was to measure audible noise events that occurred above background levels that were associated with airplane overflights. Methodologies used in other studies are similar. Some studies involving acoustic monitoring also involve a human observer to start and stop the tape or to note when a noise event was a visually observed overflight (Hamilton 2003, Miller et al. 1995). In addition to recording background noise levels, sound meters may be set to only record events occurring over a certain volume; for instance, Conomy et al. (1998a) used a dosimeter to record sound events exceeding a set threshold of 80dBA, while Palmer et al. (2003) set a recording threshold at 85 dB.

Benefits of noise monitoring include the fact that data can be collected in multiple formats, including digital. Other benefits include the fact that it is a well-tested method and several vendors have off-the-shelf systems. Problems include the fact that it can be difficult to get clean data because of the potential for other noisy events and background noise to occur, particularly in an environment such as the coast, which is much noisier than the interior National Parks where previous acoustic studies were implemented (Brown 1990). Dunholter (1998) discusses the necessity of collecting baseline background sound measurements in order to gauge the level of disturbance caused by overhead aircraft; in areas where the background environment is noisy this may be more difficult. Additionally, noise monitoring cannot uniquely identify aircraft or provide data on the altitude of aircraft. Finally, it may be impossible to correlate any particular noise event with a specific overflight, or wildlife disturbance with a particular overflight or noise event, without a human observer present (IEMR 2004). Because of the problem of definitively identifying overflights from noise data, it may be impossible to get accurate counts of overflights without a human observer, particularly because not all aircraft will produce noise within the expected levels.

<u>Sample system:</u>
Vendor: Larson Davis
System name and number: 870B – integrated sound level meter with light/heavy-weight monitoring system
Range: unweighted peak frequency range: 0.15 Hz - 70 kHz (-3 dB)
Data type: SLM Utility software converts data to ASCII (for printer or computer)
Data communication: two RS-232C interfaces,
Data storage: 512k memory, allowing data logging of 346–1 hr. intervals, memory expansion possible
Weatherproofing: housing types as suggested in Larson Davis pamphlet "Environmental noise monitoring" -- e.g. Larson Davis EPS016 (for sound meter – includes power source) and EPS2105 (for microphone)
Additional equipment: high sensitivity microphone (LD 2560), reference calibrator (LD CAL200), preamplifier (LD PRM900C) and accessories (tripod, carrying case, etc.)
Power: 2 weeks on rechargeable 12volt 17 Ah battery x 2
Size: ~50 pounds
Price: $7,420.00 (does not include transportation, installation or operation costs)

Physical environment requirements: Acoustic monitoring can be undertaken anywhere; however, in a very noisy environment such as the coast acoustic data may be cluttered. Finding a quieter location or determining a correction factor for coastal noise may be required.

Telepresence

Pros

- Proven technology for monitoring disturbance
- Can provide a view into remote or inaccessible colonies to document disturbance

Cons

- Ineffectual for monitoring planes – cannot measure altitude and can only view a small portion of the sky at a time
- Requires human observation of video (whether live or recorded) to analyze data

Telepresence is often used for remotely monitoring wildlife, such as at the Devil's Slide murre colony off the Northern California coast where it is in use for this purpose by the U.S. Fish and Wildlife Service's common murre restoration project (http://www.fws.gov/sfbayrefuges/murre/webcam.htm). This project uses two cameras from SeeMore Wildlife systems, powered by solar panels that are remotely controlled via microwave relay modems from the mainland, to monitor breeding common murres. We include telepresence as a proposed technique for monitoring wildlife disturbance rather than observing planes. Although it would be hypothetically possible to "watch the sky" with cameras, the practical difficulties outweigh the benefits. Theoretically, telepresence is the only technology that could be used to identify individual aircraft by recording tail numbers on planes. However, telepresence could not determine aircraft altitudes and only scans a small amount of sky at a time at a resolution needed to determine tail numbers.

Telepresence could, however, be a good method for recording wildlife disturbance in remote areas. Various methods for monitoring nesting birds with camera systems are given by Hughes and Shorrock (1998), King et al. (2001), and McQuillen and Brewer (2000). McQuillen and Brewer (2000) describe using a commercially manufactured, battery-powered video camera system which cost approximately $4000 per camera, and required changing video tapes and batteries every 24 hours. Hughes and Shorrock (1998) describe an infrared or vibration sensor-triggered video system that only films when triggered and records to a time-lapse video camera system. This system is described as running up to three months without a battery change due to only occasional filming. Another methodology is described by King et al. (2001), who use a wireless video monitoring system consisting of infrared video cameras connected to wireless video transmitters, which then record to a videocassette recorder through a video processor. This system is powered by 2 12volt batteries, with tape changes every day and battery changes every 3 days, and a total cost of ~$750. Finally, a puffin colony on Eastern Egg Rock in Maine is currently being monitored by a camera set up by the National Audubon Society, using a system provided by SeeMore Wildlife systems (http://www.projectpuffin.org/eer_cameras.html).

There is the possibility of combining telepresence observation with other technologies, for instance with an acoustical monitoring triggering system, or within human observation programs to monitor disturbance. Telepresence may be particularly useful for providing a view into remote or inaccessible colonies or areas. Telepresence data output is visual and thus requires either an on-site human operator or a post-hoc observer to review and code the videotaped data. Telepresence data should be time-stamped for later reviewing and correlation with other observed overflight events.

<u>Sample system</u>:
Vendor: SeeMore Wildlife
System name and number: integrated basic digital video recording remote system
Range: DC Auto iris, 4mm-9mm (Varifocal)
Data type: compresses video in M-JPEG format; outputs .mov files
Data communication: two RS-232C interfaces, ASCII (to printer or computer)
Data storage: 80GB or 300GB hard drive; with basic picture quality (30 frames/second) can record 21 hours and 201 hours of video, respectively; with 5 frames/second can record 164 hours (7 days) or 617 hours (27 days) respectively
Weatherproofing: weatherproof camera, other weatherproofing?
Additional equipment:
Power: 4 forty-watt solar panels with charge controller provided in system, 2 55amp batteries needed (range between ~$75-$200 ea.); can run up to two days on batteries alone; with solar panels and batteries may be able to run 24 hours/day in summertime cloudy conditions
Size: ~200 lbs., including batteries
Price: $5,950 plus batteries = ~$6, 150 base cost (does not include transportation, installation or operation cost)

Physical environment requirements: Telepresence can be implemented anywhere, so long as the cameras can be mounted in such a way that they have a clear, unobstructed view of the wildife to be observed and be weatherproofed. There must be enough room on the site to erect a power system (batteries and solar panels), or have easy access to the site so that batteries can be regularly changed.

FAA/Airport radar data

Pros • Already available and uses existing systems Cons • Not available in all areas of the Sanctuaries, since not all areas are close to airports or within FAA coverage • Data may not be in a useful format, or be able to track planes and their flight patterns over time • Obtaining and analyzing data requires collaborating with FAA air traffic control facilities or airports • Cannot identify small planes individually, only their existence

Both Federal Aviation Administration (FAA) air traffic surveillance radar and airport terminal radar coverage already exists in various areas along the Pacific coast. The differences between airport (terminal) radar and FAA (surveillance) radar are that although FAA radar is primarily concerned with air traffic control functions for tracking aircraft flying under instrument flight rules (IFR), and aims for coverage from 2000 feet and above, airport radar systems track all flights that enter the sphere of the airport's radar coverage. We investigated the possibility of using data from either or both of these existing systems to track flights over selected areas of the west coast Sanctuaries. We found that although this may be possible in some areas, the difficulties involved, including a lack of coverage and insufficient data, are too great for general use.

Airport terminal radar systems collect data on all aircraft, including those flying under visual flight rules (VFR) as well as IFR flights, entering the radius of their radar system, down to the floor of their radar (as low as 300 feet). This is publicly available information, and some airports, including Seattle-Tacoma International, San Francisco International, San José, and Los Angeles International, have started to disseminate visual flight track data, including altitude and plane type if available, live on their websites as a service to the community and as a part of noise reduction efforts. In order for an airport to know whether a plane is general aviation or a scheduled flight, and what that flight's altitude is, the aircraft being tracked must have a transponder turned on, a requirement in the vicinity of many airports. There is a possibility of exporting these data in a tabulated format, e.g. Excel (Gardner, pers. comm.). Location and flight path can also be calculated with data analysis, although tracking planes over time may be problematic. However, most airport radars only cover between thirty to eighty miles out from the airport, depending on the surrounding terrain. If there are obstacles in the way, such as coastal mountains, radar coverage will end. Using airport radar to track overflights in the Sanctuaries would only be feasible for Sanctuaries that fall within the detectable range; due to coastal topography, none of the Sanctuaries are fully covered. We spoke to various Northern California airport personnel including San Francisco International, San José and Monterey Bay, and while all were willing to help, none had radar coverage sufficient to monitor Sanctuary airspace under the legal (i.e., 1000 feet) floor. San José airport has coverage of parts of MBNMS, but filters out general aviation (GA) traffic from its data, making its coverage not useful for the Sanctuaries.

The other possibility we investigated is FAA radar. FAA radar, or air traffic control radar, covers airspace in-between airports and provides a tracking and informational mechanism for pilots flying under IFR rules. There is FAA radar coverage along the West Coast, particularly the California coast, that includes the areas above the Sanctuaries, and the data that radar stations collect is saved. However, due to terrain, coverage under the legal floor for overflights over the Sanctuaries is very limited. Coverage under 2000 feet over the Sanctuaries only exists within Monterey Bay itself; north of Santa Cruz towards San Francisco and south of Monterey from Carmel on, radar coverage off the coast over the Sanctuaries exists only from 2000 feet and above. In more remote locations, including OCNMS, radar coverage is even more limited.

Other problems with FAA radar include data output, which requires air traffic controller assistance in interpreting, and the fact that as a part of the air traffic control system, FAA radar does not typically keep a systematic count of non-IFR flights (Higgins, pers. comm.). It is also likely that a FOIA request would have to be submitted in order to obtain FAA radar data. In sum, FAA radar, due to its limited coverage of the appropriate altitudes and lack of focus on collecting data about general aviation flights, is likely not useful for tracking overflights.

Military aircraft, which may provide some of the overflight traffic over West Coast Sanctuaries, are noted by the FAA but often operate within special military operation area airspace, or MOA areas; regulating or tracking these aircraft would require specific agency cooperation. An example cooperation plan between the Air Force and the National Parks system is laid out in NPS and USAF (2002).

Finally, neither the FAA nor airports can provide identifying information for general aviation, VFR flights. Because these planes are not required to have a transponder, and when they do they use a general identification code, unique identification is nearly impossible. In sum, neither airport radar, due to its limited coverage of the appropriate areas, nor FAA radar, due to its limited coverage of the appropriate altitudes and lack of focus on general aviation flights, is likely useful for tracking overflights that occur under the legal floor and over the Sanctuaries.

<u>Sample system:</u>
Contact individual FAA offices or airports for details on using FAA/Airport data (see Appendix F)

Physical environment requirements: FAA or airport

Human observation program

Pros

- No technologies or installations needed
- Can utilize volunteer community and already-present researchers
- Possibility of identifying planes for enforcement purposes; possibility of recognizing make and model of plane even if individual markings are unidentifiable
- Can be combined with disturbance monitoring

Cons

- Cannot collect data at all times or all days, due to weather and availability factors, which may lead to incomplete or inaccurate data
- Difficult for human observers to gauge altitude of planes accurately or consistently
- Requires large number of observers to collect enough data for an accurate study

This method uses people to observe aircraft overflights, wildlife disturbance, or both, collecting data during a certain time period on a standardized form that can then be collated and analyzed. Human observers can be used to monitor some aspects of aircraft overflight, including the presence of aircraft, the type of aircraft, specific aircraft identification (which requires observation of aircraft tail numbers), and the response of wildlife to overflights. However, observers are not able to reliably estimate aircraft altitude for monitoring or enforcement purposes, unless there are set physical standards (i.e., aircraft flew below a natural or manmade structure of known height). As these conditions (i.e., set standards of heights applicable to Sanctuary regulations) do not exist in all Sanctuaries, we do not recommend that an observer program be instituted to monitor aircraft altitude. However, in areas where known-height structures do exist, these may assist observers in determining aircraft altitude.

Two observation programs have been attempted within West Coast Sanctuaries. In GFNMS and MBNMS, test overflights with a Partenavia and Cessna were conducted in 1996, over various areas of these sanctuaries including Cape San Martin, Castle Rock, and Piedras Blancas Island, in an attempt to estimate the altitude at which a given plane disturbed Sanctuary wildlife, including marine birds and mammals. Plane altitude and heading were recorded by the pilot, while plane apparent flight path and the response of wildlife (measured as a change in behavior or presence in the area) were recorded by U.S. Fish and Wildlife Service Refuge personnel (J. Roletto, pers. comm.). Although a full analysis of these data was not conducted, there are several lessons: First, systematic recording of Sanctuary wildlife disturbance is possible. Second, it is advisable to record both numbers of animals responding as well as their immediate response behavior. Third, all species were not disturbed to an equal degree by the same incident. A systematic study, such as the GFNMS study, could be used as further justification for Sanctuary overflight regulations, or to update existing regulations to cover new or previously untested aircraft. In addition, such a study might create disturbance data that could be used by multiple sanctuaries, as more than one sanctuary has the same species.

In 1993, opportunistic recording of aircraft overflights, including rough notes on aircraft type, numbers when visible, date and time, apparent flight plan, estimated altitude, and notes on any disturbance to marine bird wildlife, were begun on Tatoosh Island, WA located within the northern edge of the OCNMS (J. Parrish, unpub. data). In general, these data suggest that: (1) aircraft type has a substantial effect on disturbance level, independent of altitude, with louder aircraft having a larger effect (see also Brown 1990, Grubb and Bowerman 1997, NPS 1995, Stalmaster and Kaiser 1997, USFWS 2000); (2) immediate geomorphology has an effect on disturbance level, as concave surfaces (bowls) concentrate sound whereas convex surfaces dispel sound; (3) breeding phenology of the birds has an effect on disturbance level – earlier in the season (before egg laying) birds are more apt to exhibit signs of disturbance (culminating in temporary evacuation of nesting or loafing sites), whereas later in the season (when pairs have eggs or chicks) birds may remain on nests even during elevated levels of disturbance. However, it is also true that the consequence of elevated response (e.g., evacuation) to a late season disturbance may be more dire, in the sense of reproductive failure, than that to an early season disturbance; (4) all species do not respond equally; (5) lower altitudes generally increased the level of disturbance, within an aircraft type (J. Parrish, unpub. data). Many of these conclusions mirror those of the GFNMS study.

The OCNMS data collected at Tatoosh Island were used to conduct an enforcement action against a helicopter pilot and contracting passenger; thus, there is some precedent for data collected by human observers being used for enforcement purposes. (It should be noted that the OCNMS regulations only require proof of ceiling violation, not specific wildlife disturbance). Subsequent attempts to standardize overflight data collection within OCNMS was not successful, in part because of the level of detail required.

Recommendations for a human observer program
If the decision is made that information on overflight frequency, and/or information on wildlife disturbance are necessary, we recommend that a generalized observer program be developed across all West Coast Sanctuaries. Implementing a human observation program would involve assessing volunteer and staff resources, choosing sites for data collection, and training observers to record overflight observations using standardized data collection sheets. Staffed by Sanctuary personnel, permitted researchers, and other official personnel, an observer program could be used to collect broad scale information on the types and frequency of aircraft overflights, as well as on the standardized response of marine birds and mammals.

To most effectively use the data, collection protocols would have to be identical, or at least stratified such that data at higher levels of aggregation were comparable. A centralized database should be constructed, and regularly populated with data. A data analysis protocol should be developed and implemented such that results are routinely available to Sanctuary personnel.

At a minimum, we recommend collection of:

- Date
- Time (military) at start of incident
- Location of observer
- Name of observer
- Type of aircraft (see Appendix G) (While identification to specific model may not be possible, an observers program should be able to record information about aircraft by broad category; e.g., private propeller, private jet, military, etc.)
- Apparent flight path of aircraft (could be diagrammed)
- Species-specific standardized response (see below)
- Time (military) at end of incident (if overflight lasts more than a single pass)

We recommend that all species of interest within easy visual range of observers be:

- Assigned to a taxonomic class – maximally species, minimally marine birds or pinnipeds
- Classed by abundance - <10; 10-25; 26-50; >50
- Categorized by location – on land (beach, cliff-face, etc.); on/in water; in air
- Categorized by breeding status (as a group) – pre-breeding; with young (including eggs, for marine birds); post-breeding

We recommend that biological response be categorized as number, or percent, of organisms (by species):

- Exhibiting no response (that is, no change in behavior)
- Changing behavior to an elevated level of threat (e.g., alert posture, sitting up, standing up)
- Moving in response to overflight
- Evacuating in response to overflight

In the cases of movement and evacuation, we recommend that any injury to organisms, including young (pups, chicks, eggs), be noted. This would include circumstances in which organisms were crushed during an evacuation, as well as exposed to predation as a consequence of loss of parental protection.

Although human observers are not typically able to accurately estimate aircraft altitude, observers could be equipped with range finders or range-finding binoculars. Range finders may either be laser (more accurate) or optically (less expensive) based. Both types have been used to survey wildlife, including birds (Alerstam et al. 1993, Ransom and Pinchak 2003). Laser rangefinders depend on the reflectivity of their target to get an accurate range measurement, which may vary with the angle of observation of the aircraft and weather conditions (Arnold). The range of recreational laser rangefinders varies between 450 to 900 meters based on the reflectiveness of the target, with accuracy typically within one meter. The range of professional rangefinders can be up to 2000 meters.

Most recreational range finders do not correct for the slope of the measurement, so that strictly horizontal or vertical measurements are required order to get accurate readings of distance. However, for this particular application, the exact altitude of the aircraft in question is less important than whether the aircraft is flying under the legal floor (1000 feet in the California Sanctuaries; 2000 feet in OCNMS). Thus, aircraft that are detected at 1000 feet or less with an angled measurement are certainly flying under the legal floor. In sum, observers would need to experiment with range finding binoculars to determine if this is a viable way to track the altitude of low-flying aircraft.

Recommendations

Our recommendations for an overflight monitoring program vary based on what the Sanctuaries decide the goal(s) of a monitoring program should be. These goals may vary between individual Sanctuaries, and could include:

- Determining overflight frequency and altitude
- Determining wildlife disturbance during an overflight
- Collecting data for enforcement purposes (altitude violation only)
- Collecting data for enforcement purposes (altitude violation linked to wildlife disturbance)

For each of these goals, a combined approach using both technological monitoring systems and a human observer program, is the best approach to cover all aspects of the problem:

Determining overflight frequency and altitude
To count aircraft overflights in the sanctuaries, and determine aircraft altitude, we recommend a combination of transponder scanners and human observation. Transponder scanners can count and record the altitude of all aircraft with activated transponders. Human observers can count all overflights and note aircraft type, regardless of transponder activation, providing a benchmark against which the transponder count can be measures. Scanner and observer data would need to be time synched. We recommend a pilot phase at one or more Sanctuaries with sufficient trained personnel to collect accurate human observer data to adequately groundtruth transponder scanner efficacy. At a minimum 150-200 hours spread evenly over the lighted portion of the day and across the week-weekend boundary. Assuming the results of the pilot program (percent of overflights detected by transponder scanner meets an acceptable threshold) are successful, transponder scanners could then be used exclusively in a more comprehensive monitoring program.

Determining wildlife disturbance during an overflight event
To determine the frequency and severity of wildlife disturbance during overflight events, we recommend human observation, with acoustic monitoring if data on noise thresholds are desired, and telepresence if only remote viewing of wildlife is possible. As above, human observers can count all overflights and note aircraft type, during observation hours, while also determining the extent to which wildlife are disturbed. Acoustic monitoring will provide additional data on sound thresholds provoking disturbance and also allow sound thresholds to be correlated with aircraft type. The approach of human observers and acoustic monitoring has been used in several previous overflight studies to determine the effects of overflight noise on specific wildlife populations (Brown 1990, Conomy et al. 1998a, Fidell et al. 1998, and Trimper and Standen et al. 1998). Telepresence could be used to monitor remote colonies of sensitive species, in addition to

data collected directly by human observers. Observer, acoustic, and telepresence data would need to by time synched.

Collecting data for enforcement purposes (altitude violation only)
In OCNMS and MBNMS, the legal restrictions on overflight state that flying motorized aircraft within certain areas at less than 2000 and 1000 feet, respectively, is prohibited. It is not necessary to also prove disturbance to wildlife. For monitoring overflights for possible violations and enforcement purposes in these areas, we recommend human observer data time synched with portable radar data. For enforcement purposes, it is worth emphasizing again that none of the technological approaches we investigated are capable of uniquely identifying general aviation VFR aircraft, which is possibly the majority of air traffic flying over the Sanctuaries. These planes are only identifiable by visual observation of their tail numbers. However, human observers are not reliable judges of altitude. We believe that portable radar is the most effective technology available to accurately determine altitude of aircraft as it does not depend on whether an aircraft is carrying an activated transponder. Because portable radar is a significant additional cost over transponder scanners, the latter may be used to estimate altitude if cost is a factor. However, transponder scanners may not detect every plane and thus are not the best choice for enforcement purposes.

Collecting data for enforcement purposes (altitude violation linked to wildlife disturbance)
In CINMS and GFNMS, the legal restrictions on overflight state that disturbing wildlife by flying motorized aircraft within certain areas at less than 1000 feet is prohibited. In these areas, documenting an altitude violation and linked wildlife disturbance will require time synched human observation and portable radar, with telepresence if only remote viewing of wildlife is possible. As mentioned above, human observers are the only viable way to record aircraft tail numbers for enforcement purposes. A portable radar system would be needed to accurately determine the altitude of aircraft overflights. If cost precludes the use of portable radar, transponder scanners could be used, but with the limitation noted above. Human observers, and possibly telepresence for remote wildlife situations, would be needed to record the frequency and severity of wildlife response.

<u>Additional Recommendations</u>

Based on our interviews with Sanctuary personnel, pilots, and FAA personnel, we have also developed a set of additional recommendations for education, outreach and coordination, which we consider to be the most viable and effective ways to reduce the frequency of low overflights over the Sanctuaries.

- Education and outreach
    - Pilot groups
    - Airshows
    - Flight training schools
    - Airports in the vicinity of the Sanctuaries
- Coordination
    - Cross-Sanctuary
    - National Parks
    - National Wildlife Refuges
    - FAA
    - Military and Coast Guard

Education and outreach
One approach that came up repeatedly was educational outreach about Sanctuary overflight regulations as an effective, low-cost way of reducing the incidence of overflight violations and wildlife disturbance. This kind of "bottom up" education to the general aviation pilot community may be more effective in actually preventing overflights than attempting to enforce Sanctuary rules through legal action. Small aircraft pilots and pilot organizations were described to us as being generally receptive and willing to be helpful. Because of pilot diversity and organization turnover, any education and outreach program needs to be: (1) multi-pronged (simultaneous outreach to several venues), (2) provide multi-media materials, and (3) be on-going. Finally, we recommend that outreach messages, materials, and presentations be standardized and/or shared across all West Coast Sanctuaries, to the greatest degree possible. Centralized planning, development, and implementation will reduce costs and familiarize pilots with the Sanctuary "brand," such that basic info on low overflight risks and wildlife disturbance are transferable.

- Pilot groups

Pilot groups, including local chapters of the Experimental Aircraft Association (EAA) and the Aircraft Owners and Pilots Association (AOPA), should be contacted and asked that information about Sanctuary overflight restrictions be included in their informational materials and website. AOPA has already been involved in the regulatory process vis-à-vis overflights of National Parks. Although AOPA expressed concern over restrictive flight rules, they also worked to compromise on an overflight ceiling (AOPA, "National Park Overflights"). OCNMS has been able to work with AOPA to include information about Sanctuary regulations for airports west of the Cascades in the directory of airports maintained on the AOPA website (Galasso 2001). OCNMS has also given educational presentations to EAA chapters (OCNMS 2001). It is important to note that OCNMS outreach to pilots has been via a contract pilot (Dave Kruth). As a pilot, Dave knows the language, the relevant organization, and most importantly, the likely concerns and attitudes of the pilots. Contracting with individuals with immediate recognition/stature in the aviation community is, in our view, essential.

One area where the Sanctuaries may be able to place more emphasis is in promoting the Sanctuary regulations as directly relevant to pilot and flight safety. Safety is always a concern with low altitudes, as time to landing in the case of catastrophic engine failure is proportional to height above ground. In the case of over-water failure, low overflight presents an additional hazard as the chance of reaching land before impact is not high. Safety also becomes a concern when low-flying aircraft flush colonial seabirds (hundreds to thousands of birds). Seabird flocks may obscure the pilot's field of view; cause the pilot to attempt dangerous avoidance maneuvers; or at worst, collide with the aircraft. One additional venue for disseminating safety information may be the website of the Air Safety Foundation (http://www.aopa.org/asf/).

- Airshows

OCNMS has successfully conducted several training sessions about OCNMS regulations at local airshows and the materials used at these trainings are available (Galasso 2001, Galasso 2005). Airshows are an efficient way to reach the pilot community with manned displays and educational materials. Staffing displays with contract pilots is key.

- Flight training schools

Flight training or pilot schools are a centralized and unique opportunity for education and delivery of outreach materials. Because flight schools train new pilots, they provide the perfect venue for educating pilots about Sanctuary regulations before flight routes and pilot behavior have been established. Possible methods could include informational inserts to go into training materials or have personnel available to speak to classes of new pilots. Safety should be emphasized, as should the boundaries of the Sanctuaries as they are not adequately marked on FAA charts.

o Airports in the vicinity of the Sanctuaries

Small airports may be willing to stock informational materials about Sanctuary regulations or put up posters or displays. Contacting these airports, or entering information into a database such as AOPA's, above, would be a proactive educational step. An appendix containing a listing of the small airports within an approximate 100 mile radius of the four Sanctuaries profiled in this report is included in Appendix H.

Coordination

o Cross-Sanctuary

After interviews and follow-up conversations with Sanctuary personnel, we recommend a set of coordinated activities centered on overflights, including but not limited to:

- Development and production of standardized outreach materials for pilots
- A West Coast Sanctuary Overflight Working Group

Standardized materials, developed in cooperation with pilot's associations and contract pilots, should present current Sanctuary overflight regulations, as well as flight safety and wildlife sensitivity reasons for adhering to the regulations. Depending on outlet venues (see above), materials should be: pamphlets, flight manual inserts, posters/large displays, presentations. Although all West Coast Sanctuaries have different specific regulations, it is also true that sensitive wildlife largely overlap, and flight safety concerns are equivalent in all Sanctuaries. Therefore, a strong central message and design delivery of the information will train pilots to recognize all Sanctuaries as equal, and may facilitate transfer of information (e.g., flight etiquette).

Sanctuary personnel we interviewed shared information about specific overflight situations, and how they were dealt with given Sanctuary constraints. Many were innovative solutions that could easily be adapted to other West Coast Sanctuaries. However, without a vehicle for transfer of information, most of this information remains individual and anecdotal. We recommend the creation of an Overflight Working Group composed of Enforcement, Resource Protection and Research staff, meeting at least once annually. The Working Group should discuss basic problems related to overflights, and share solutions to overflight issues. In addition, the Working Groups could be the genesis of the overflight outreach materials (discussed above). Finally, should an opportunistic human observer data collection program on overflights and wildlife response begin, the working Group should be the entity involved in program design, and oversight of the database and data analysis.

o National Parks and National Wildlife Refuges

All of the Sanctuaries have National Parks and/or National Wildlife Refuges either adjacent or nearby. These Parks and Refuges also have a mandate to protect wildlife within their boundaries, therefore agencies involved should work together to standardize regulations and present a uniform message to both tour concessionaires and the public. The Washington Islands National Wildlife Refuges (including Flattery Rocks, Quillayute Needles, and Copalis National Wildlife Refuges) have a wilderness protection objective to develop an aircraft impacts awareness program in 2006 including education materials for pilots and incident reports to the FAA. Additionally, their objectives include working with the FAA to develop "notices to pilots" on aeronautical charts by 2008 (USFWS 2005). This presents an ideal opportunity for OCNMS and the other West Coast Sanctuaries to work with the National Wildlife Refuges to standardize messages to both the public and the FAA.

o Military and Coast Guard

Coordination with the military and Coast Guard is essential, as they operate under special FAA rules and are flying in or around all of the West Coast Sanctuaries. Many of the Sanctuaries have already had success with getting military and coast guard pilots to reduce low overflights in Sanctuary areas. MBNMS reports that their semi-annual presentations to the Coast Guard have been well received and have been successful in reducing low overflights over sensitive areas by Coast Guard aircraft. Coordination and outreach efforts with the military and Coast Guard should be continued and expanded. If there is interest in an official agreement between the Sanctuaries and the military or Coast Guard, the joint operating agreement on overflights between the National Parks and the Air Force provides a good example and can be found in NPS and USAF (2002).

o FAA

There are ongoing efforts by the National Marine Sanctuary Program to get the FAA to recognize Sanctuary regulations. It is important that the Sanctuary areas and regulations be recognized and clearly documented on FAA communications to pilots in order to reduce the occurrence of overflights, allow for better enforcement, and reduce pilot confusion. It has been reported by many Sanctuary personnel that pilots are confused when informed about Sanctuary regulations because they are not designated by the FAA. In communicating with the FAA, we recommend compiling the opportunistic and anecdotal data collected to date on overflight violations and wildlife disturbance, and providing information from the literature about long-term effects of low-level disturbance. In addition, we recommend focusing on pilot safety. Low-flying aircraft have the potential to flush large numbers of birds (hundreds to thousands) into the air causing a safety hazard to pilots from obscured view to possible collision. It may be possible to enlist the Coast Guard in documenting concern about bird strikes. A focus on flight and pilot safety may resonate more loudly with FAA personnel than the welfare of wildlife.

Clearly, official FAA recognition is (and should be) the goal of the Sanctuary Program, however, short of official recognition, there may be a few options for increased awareness through FAA, including the marking of all Sanctuary boundaries on VFR charts and the inclusion of Sanctuary guidelines in weather briefings or Notices to Airmen (NOTAMs) for pilots. Although the official regulations are not recognized, VFR charts do show GFNMS, MBNMS, and CINMS restricted areas with a request to maintain a minimum altitude of 2000' in accordance with FAA guidelines for National Parks and National Wildlife Refuges. OCNMS, however, is not currently marked on the charts. OCNMS could request similar chart designations to those currently in place for the other Sanctuaries. In addition, efforts could be made to have Sanctuary regulations provided in regular pilot information services such as weather briefings or NOTAMs that would be given to pilots flying along the coast. For more information on these options, please see list of contacts in Appendix F.

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Appendix A. Sanctuary Regulations

Subpart G - Channel Islands National Marine Sanctuary

§ 922.71 Prohibited or otherwise regulated activities.

(a)(5) Disturbing seabirds or marine mammals by flying motorized aircraft at less than 1000 feet over the waters within one NM of any Island except:

(i) For enforcement purposes;

(ii) To engage in kelp bed surveys; or

(iii) To transport persons or supplies to or from an Island.

Subpart H - Point Reyes/Farallon Islands National Marine Sanctuary

§ 922.82 Prohibited or otherwise regulated activities.

(a) (5) Disturbing seabirds or marine mammals by flying motorized aircraft at less than 1000 feet over the waters within one NM of the Farallon Islands, Bolinas Lagoon, or any ASBS except to transport persons or supplies to or from the Islands or for enforcement purposes.

Subpart M - Monterey Bay National Marine Sanctuary

§ 922.132 Prohibited or otherwise regulated activities.

(a) (6) Flying motorized aircraft, except as necessary for valid law enforcement purposes, at less than 1000 feet above any of the four zones within the Sanctuary described in Appendix C to this subpart.

Appendix C to Subpart M of Part 922 - Zones Within the Sanctuary Where Overflights Below 1000 Feet Are Prohibited

The four zones are:

(1) From mean high water out to three nautical miles (NM) between a line extending from Point Santa Cruz on a southwesterly heading of 220_ and a line extending from 2.0 NM north of Pescadero Point on a southwesterly heading of 240_;

(2) From mean high water out to three NM between a line extending from the Carmel River mouth on a westerly heading of 270_ and a line extending due west along latitude 35_ 33'17.5612" off of Cambria;

(3) From mean high water and within a five NM arc drawn from a center point at the end of Moss Landing Pier; and

(4) Over the waters of Elkhorn Slough east of the Highway One bridge to Elkhorn Road.

Subpart O - Olympic Coast National Marine Sanctuary

§ 922.152 Prohibited or otherwise regulated activities.

(a) (6) Flying motorized aircraft at less than 2,000 feet both above the Sanctuary within one NM of the Flattery Rocks, Quillayute Needles, or Copalis National Wildlife Refuge, or within one NM seaward from the coastal boundary of the Sanctuary, except for activities related to tribal timber operations conducted on reservation lands, or to transport persons or supplies to or from reservation lands as authorized by a governing body of an Indian tribe.

Appendix B. Interview Questions

Sanctuary Background

-What do you know about overflights in your sanctuary? Has any sanctuary effort been put into considering overflight monitoring or disturbance?
-Were overflights considered in the site's original management plan or in recent management plan reviews? If so, are any changes under consideration?
-Is there a specific person responsible for overflight violations?
-Have you had complaints related to low overflights or noise disturbance from the public?

Site Specific Concerns

-Is the land adjacent to or islands within the sanctuary private or public land, or both?
-How accessible is land adjacent to or islands within sanctuary? (accessible by private parties? only for research/sanctuary staff? tourists?)
-Who uses the land? What do they use the land for?
-What type of infrastructure is available on land adjacent to or islands within the sanctuary? (power, security, etc.?)
-What research programs (or other types of programs, such as volunteer programs) are active in the sanctuary? (Limited to "regular" programs- defined as throughout the year or at least the summer season and year-after-year)

Where?
When?
What?
How many people? Who?

-Are there any small airports / private air strips nearby?
-Can you send us maps/other sanctuary specific information w/ research project locations, etc.

Wildlife Disturbance

-What type of wildlife is at likely risk due to overflight disturbance? Are any of them endangered species?

Species?
Location?
Number? (actual count of general category- like lots or rare)
Time of year disturbance is more likely to occur (seasonal/temporal/weather-related differences)?

-Is there persistent or occasional exposure to noise from air traffic?
-Have you ever detected a disturbance to wildlife from overflights? Is there a dedicated effort to quantify the disturbance? (If yes, then by what mechanism?)
-Would the installation/testing of technology impact wildlife? Are there specific times that installation would have to occur?

Technology

-In your opinion, would a technological (like radar) or a human (like an observer program) be better for your sanctuary? Why?
-Do you have any technology suggestions?

Final

-How important is this issue to your Sanctuary?
-What is your sanctuary interested in gaining from an overflight program?
-Who else should we talk to? (within the Sanctuary? In the area (i.e., researchers, other resource managers, Coast Guard, local airport, etc.)? within the national sanctuary program?)

-Would it be okay if we came and did a site visit with you?

Appendix C. Summaries of interviews with Sanctuary and National Park personnel

Olympic Coast National Marine Sanctuary

Carol Bernthal
Superintendent
Olympic Coast National Marine Sanctuary

Barbara Blackie
Research Specialist
Olympic Coast National Marine Sanctuary

Ed Bowlby
Research Coordinator
Olympic Coast National Marine Sanctuary

Cat Hoffman
Natural Resources Chief
Olympic National Park

Has there been any effort to quantify overflights within the sanctuary in the past?
CB: Overflights are something the sanctuary has struggled with since 1994. The FAA does not currently recognize sanctuary regulations regarding overflights. We've had back and forth debates with several attorneys, yet the regulations still do not appear on the aviation charts. Data on overflights and disturbance are opportunistic; the best data are from Tatoosh Island. Staff of ONP and OCNMS were trained to identify and document low-flying planes. Enforcement is still a concern; it's difficult to estimate a plane's elevation and record the trail number from ground level. Most violations are from private planes, on sunny days.
EB: Overflights primarily occur during the summer time. The presence of military aircraft in the restricted area had decreased over the time I've been involved in the sanctuary. I've personally only documented disturbance due to aircraft once.
BB: We have the most reliable data from Tatoosh Island (known amount of effort, disturbance can be documented). For data from elsewhere, we know nothing about the amount of effort (time) to generalize overflight patterns. Few overflight sightings also identify wildlife disturbance.

Who can obtain an overflight permit?
CB: Permits, so far, have only been given for search and rescue training, research, and aids to navigation (lighthouse) servicing

Has there been any public outreach?
CB: Our general approach: you can enjoy wildlife without causing disturbance. We hand out a 3-sided flyer with a map of the sanctuary and the purposes of the regulations, which tells people to "do the right thing" It's been distributed to 18,000 pilots. Dave Kruth has presented for target audiences: pilots, instructors, public charters (through consumer pressure). He has a circuit of airport and flight schools where he posts the information.
EB: Public outreach should be targeted at pilots. Dave Kruth puts up displays at OCNMS and airplane events. OCNMS has a good understanding with the Coast Guard and the military, and has seen a decrease in the number of violations from these 2 groups. Local aviators are aware of restrictions, air groups and traveling shows bring new people into town that are not aware of restrictions.

Have you received any public complaints?
BB: Public complaints about low overflights are rare.
EB: There have been some complaints from visitors to the ONP beaches.

How are overflight violations enforced?
CB: For enforcement you need the elevation level and the tail number. This information is forwarded to an office of law enforcement. So far, we have not had a case go all the way through and result in a penalty. In most cases, the pilot or owner of the plane was contacted and given a verbal warning.

Are there any programs that could take data on overflights within the sanctuary?
CB: Some suitable programs include COASST, which surveys beaches near sanctuary waters once/month and ONP backcountry rangers who are out during the summer months only. Tribes perform regular aerial surveys, but they probably don't have enough volunteers. Over 1 million people visit the park yearly, so those that cater to tourists - Bed & Breakfasts, charter fish companies, sea kayak rental and tour companies might be interested in helping out.
EB: A new program in Clallam county, "Beachwatchers" may be interested in collecting overflight data as well. The program has volunteers who do water quality work on the outer coast. ORHAB (Olympic Regional Harmful Algae Bloom) team, anyone from the shellfish industry, or any of the National Parks Rangers may be useful resources for developing an overflight monitoring program.
Barb: The ONP backcountry rangers, and volunteers at the wilderness information center (the place people stop to get backcountry permits in ONP) may be able to take or coordinate collection of overflight data.

Where would overflights cause the most disturbance?
CB: Area of concern within the sanctuary include Tunnel Island (Point Grenville), Tatoosh Island, Cape Alava, Ozette, Jane's Island, Carol Island, Crying Lady Rock, and Destruction Island.

Are there any places with infrastructure in place where a remote device could be located?
CB: Suitable places to place radar, or other technologies include Hoh Peak, Tatoosh Island, Destruction Island, and Mt Olympus.

Which species are most at risk due to low overflights?
CB: At risk species include: BRGO, SAND, Gulls, BAEA, RHINO, PEFA, CAAU, CATE, PIGU, MAMU (largest concentration of nesting MAMU in lower 48), COMU, BRPE, SUSC, BLOY, PECO, BRCO, DCCO, Northern fur seal, California Seal, Elephant Seal, Harbor Seal, Sea Otter.
BB: Those most at risk of disturbance are COMU, Seals and Sea Lions

Are there any overflight restrictions in Olympic National Park?
CH: There are no regulations specific to Olympic National Park. Regulations in the park are governed by the FAA, which has a recommendation of >2000ft, but this is not a requirement.

Have you collected any information about overflights in Olympic National Park?
CH: All our information on overflights is anecdotal. Tribal flights occur 2-4 times/year on each river in ONP.

Gulf of the Farallones National Marine Sanctuary

Karen Reyna
Resource protection specialist
Gulf of the Farallones National Marine Sanctuary

Jan Roletto
Research coordinator
Gulf of the Farallones National Marine Sanctuary

Has there been any sanctuary effort put into overflight monitoring or disturbance?
JR and KR: Permits are only available for education and research purposes. No tourist or commercial flights are allowed over the sanctuary. Only certain types of aircraft are allowed to do aerial wildlife surveys. Research conducted within the sanctuary that the degree of disturbance depends on the type of plane (quiet aircraft cause fewer disturbances) and pilot experience.

Were overflights included in the recent management plan review?
JR and KR: The wording of the current management plan needs to be stricter. The management plan should include a strategy for assessing violations and communicating with the sanctuary when a violation has occurred. We're interested in having an enforcement officer work with volunteers to better monitor the nearshore environment. For offshore islands, there should be a coordinated effort among seabird biologists to document the disturbance and relay the information to the sanctuary. A coordinator at the sanctuary would then compile all this information and begin the enforcement process. There needs to be a concerted effort between refuge staff, the NPS, field researchers and private, non-profits like Point Reyes Bird Observatory to provide the sanctuaries with data that could be used for enforcement purposes.

What type of overflight data is GFNMS interested in?
JR and KR: There is no readily available information regarding how many, what types, when, how high and how often disturbance occurs. The origin of these planes is also important in targeting outreach efforts. GFNMS currently does not have a good idea about how often the current regulations are being violated – a lot of data have been collected, but it's all in raw form, and not collected by any standard procedure.

Has the sanctuary received public complaints related to low overflights?
JR and KR: Yes, we have received public complaints. Citizens speak up not just because they're annoyed, but because they're genuinely concerned about sanctuary resources.

Is there any public outreach regarding overflights?
JR and KR: Docent and informational programs regarding disturbance are run by the sanctuary and the national park. These programs emphasize viewing wildlife from a distance, and are especially targeted toward kayak and canoeing enthusiasts. GFNMS has an agreement with army and navy helicopter pilots; all pilots are in contact with GFNMS before they begin scheduled flights over the sanctuary. Pamphlets regarding sanctuary recommendations are distributed to pilots.

Are there any ongoing programs which could collect information on overflight as well?
JR and KR: There are docent led education groups at Año Nuevo and Point Reyes seashore. Field biologists are on or near all the islands, even the remote ones, but they do not produce the good, reliable, and consistent data needed for enforcement purposes. An observer program is

certainly attainable. GFNMS has a lot of supporters and a large volunteer base in the San Francisco Bay area.

Types of wildlife most sensitive to disturbance?
JR and KR:
The following species are sensitive to disturbance:
COMUs (Most sensitive May-August)
Winter waterfowl (December-January)
Snowy Plovers (Endangered? Rare, but lots of public attention)
BRPE roosts
MAMU (federally threatened – breeds in sanctuary)
XAMU (federally threatened)
CA Sea Lions
Stellar Sea Lions (threatened)
Harbor Seals
Northern Fur Seal (Absent since 1997, Species of Concern in CA)

What is the largest source of noise disturbance to wildlife in the sanctuary?
JR and KR: During fleet week, the second week of October, Navy planes consistently fly over sanctuary waters during practice runs for the weekend aerial show.

Have sanctuary personnel ever detected disturbance to wildlife due to overflights? Is there a dedicated effort to quantify disturbance?
JR and KR: Yes, we've attempted to quantify disturbance to harbor seals as a result of vessel/plane traffic. 20 different types of human disturbance were paired with behavior assessments. Assessing disturbance in this manner is too labor intensive and not cost effective. Jan Roletto has developed a map of sensitive areas that has been distributed to the Coast Guard and other organizations who would likely contribute to disturbance.

Is noise from air traffic occasional or persistent?
JR and KR: Noise from air traffic is persistent, especially during the summer months, on nice days. We notice a lot of noise from small aircraft. Coast Guard helicopters contribute to air traffic noise when they perform rescues of cars/people along highway 101.

What type of infrastructure is available on the islands?
JR and KR: Power is not available on bird rock. SE Farallon Island has solar power with diesel and gas back-up.

Has GFNMS looked into any technological solutions? If technology were installed, when should it occur?

JR and KR: Telepresence currently exists on Devils Slide Rock – COMU habitat restoration site. The sanctuaries are hoping to expand telepresence coverage. We are interested to see if telepresence could be used to record disturbance in real time. If technology were installed on the islands, it would have to be installed sometime other than March 15 to August 15.

Monterey Bay National Marine Sanctuary

Lisa Emanuelson
Resource Issue Education Specialist
Monterey Bay National Marine Sanctuary

Scott Kathey
Regulatory/Emergency Response Coordinator
Monterey Bay National Marine Sanctuary

Deirdre Hall
Permit Coordinator
Monterey Bay National Marine Sanctuary

Bob Yerena
Sanctuary Enforcement Officer
Monterey Bay National Marine Sanctuary

How much effort has been put into monitoring overflights in the past?
We know a fair amount. Scott Kathey has gathered some disturbance data while completing sea otter surveys in a Coast Guard Partenavia, but this study was not specifically looking for disturbance. We also collected some disturbance related data during the Big Sur Marathon, when lots of aircraft were monitoring the participants. There are a few USFWS monitored COMU nesting sites a half mile from shore – there have been several disturbance incidents there. We also have records from Brian Hatfield at Piedras Blancas. A few of the above reports describe the threshold of disturbance. So far, we have lots and lots of anecdotal data -100's of observer accounts - but no method of systematic data collection, so the information may not be helpful in determining trends. Our overflight woes stem from the fact that regulations are not on aerial charts, and that overflight zones often overlap.

Have there been any public complaints?
There's a lot of public concern regarding overflights in the sanctuary, especially from the people at BayNet. We have received numerous calls from the general public (24-50/year) regarding concerns about seabird and marine mammal disturbance. Currently, there's no protocol for calling in violators – citizens call without a description of the plane, or a tail ID number – so we cannot forward the information to enforcement officials. We've received multiple complaints regarding private citizens flying coastal range helicopters from private land strips north of Santa Cruz.

Are overflights common or rare in MBNMS?
Common in Monterey, not along Big Sur. Sea mammals in Monterey are acclimated to urban use; Big Sur wildlife is more easily disturbed.

What is the enforcement procedure if a plane is properly identified?
We issue of a written warning if the witness provides a tail number.

What type of aircraft is most common?
Half of the air traffic over the sanctuary consists of military planes and half consists of private planes. Lots of different types of aircraft fly over sanctuary waters, everything from commercial planes to blimps to helicopters to remote controlled model airplanes. The US Coast Guard monitors cliffs along Big Sur coastline and performs rescue missions for people trapped on cliffs, rocks, or points.

Has there been any outreach to the public regarding overflight?
There has been some outreach to private, local pilots. We meet with the Cost Guard on a regular basis and give a presentation about overflight restrictions within the sanctuary. We also visit USFWS air station, San Francisco and Sacramento airports. We've had a positive response in trying to minimize the number of overflights that occur during sensitive periods, but with an increase in homeland security, it's becoming harder and harder..

How often do violations occur?
Not every time I go out, but they are frequent.

What types of planes are granted permits? What is the procedure?
Special use permits require 0 impact, and do not take place during the sensitive time of the year (March 15 – September 30). Commercial use permits are given out during the off season.

Any volunteer programs that could take an overflight observer sheet?
Suitable programs include the BayNet program (sanctuary volunteer network), the Monterey Bike Path folks, the Elkhorn Slough Kayak naturalist program, other kayaker programs in the bay, Friends of the Elephant Seals Program (perform aerial surveys in the winter months), the Point Sur Lighthouse keepers (collect data on marine mammals several days a week), and volunteers and guides on Año Nuevo.

Any species particularly susceptible to disturbance from aircraft?
SNPL, MAMU, BRPE, XAMU, Terns (CATE, or ARTE?)

Have you looked into any technology solutions?
The Naval Post Graduate School in Monterey has a mobile radar van as part of their air defense unit. The device was given to the Navy on the condition that they would make it available for use by other parties. It could be used to track aircraft, their approach and altitude, for research purposes only. The model is approved by the ASA, so it cannot be used to track and prosecute civilian aircraft.

Is there an infrastructure in place for technology?
There's already an infrastructure at Point Sur, and there are several places along the coast like Hurricane Point (1000 ft) that would be ideal for radar.

Channel Islands National Marine Sanctuary

Sarah Fangman
Channel Islands National Marine Sanctuary
Research Coordinator

Kate Faulkner
Chief of Resource Management
Channel Islands National Park

Julie Helmers,
Channel Islands National Marine Sanctuary
Sanctuary Assistant Manager, Pilot

Ben Waltenberger
Channel Islands National Marine Sanctuary
Physical Scientist, Pilot

Has the sanctuary put effort into monitoring overflights in the past?
SH: Planes, marine mammals, and vessels have been monitored for the past 6 years through Sanctuary Aerial Monitoring and Spatial Analysis Program (SAMSAP).
On a weekly basis, a pilot and observer collect GIS data for long term monitoring and sanctuary use patterns. The SAMSAP plane has also been used for emergency response and has documented the extent of oil spills from the air. The observer on board can dispatch fish and game wardens to check vessels for possible violations, so the presence of the plane also serves as a deterrent to illegal fishing and low overflights.
JH and BW: SAMSAP monitors 34 specific vessel categories: everything from surfers, kayakers, and small recreational boats to commercial fishing vessels and tankers. The position of marine mammals, whales, dolphins, and sharks are also noted. Using the digital camera people aboard the plane take photographs of any vessels that may be in violation of fishing regulations. SAMSAP also serves as a first responder if there is an emergency situation within the park. The presence of the SAMSAP plane has reduced violations significantly.
SF: There has not yet been a study that has looked at overflight disturbance within the sanctuary. We would like to have a study on overlfights that includes:
-the type of place
-the seasonality of overflights
-the threshold of disturbance
KF: The only overflight monitoring that I know of within the National Parks System is in areas where there is a large military presence. These areas include: Joshua Tree, Death Valley, Sequoia and Kings Canyon National Parks.

What type of enforcement does the sanctuary have regarding low overflights?
SH: Monitoring of low flying aircraft is on an ad hoc basis – there is not active enforcement of overflight violations by sanctuary personnel. This type of enforcement rests more in the hands of the park rangers and wardens.
JH and BW: 1-3 years ago, we sent a plane's information to the FAA who gave the pilot/owner a warning.

Has anyone ever documented disturbance due to low overflights within the sanctuary?
KF: No, I have never detected disturbance. Nobody else has to my knowledge, except NMFS researcher on the west end of San Miguel Islands, where there is a large sea mammal haul out.

SF: There is no dedicated effort to quantify disturbance to wildlife from overflights because they occur too infrequently.

Does the Channel Islands National Park (CINP) have specific overflight regulations?
KF: CINP does not have any specific overflight restrictions. The ceiling for the Channel Islands National Marine Sanctuary (CINMS) does not apply over the islands. National Parks Service (NPS) and National Marine Fisheries Service (NMFS) planes land on the islands to bring supplies and equipment.

What types of aircraft are common over sanctuary waters?
SH: Private, NPS chartered aircraft and military planes fly over the sanctuary. Most people get to the islands by boat. There are a number of landing strips on the islands themselves: San Miguel Island (2). Santa Rosa Island (1), Santa Cruz Island (2). There are several companies that fly tourists to CINP.

Is there an occasional or persistent noise from overflights?
SH: Sanctuary staff believe the frequency of low overflights (<1000ft) is low. There have not been any public complaints regarding low overflights. The military is exempt from sanctuary recommendations during routine trainings, but there have not been many incidents regarding low overflights by military aircraft.
JH and BW: The sanctuary has not received any complaints regarding low overflights. Part of the sanctuary is used for national defense training, but we're never seen them take advantage of overflight restrictions within the sanctuary. The Coast Guard is also very good about complying with overflight restrictions when they are on routine flights.
SF: Low overflights over the sanctuary are rare. The volume is very low. People must request a permit to fly over the sanctuary. There have not been any public complaints related to noise from low overflights.
KF: The Chief Ranger, Jack Fitzgerald, says that we get 3-4 low overflights per year. The violations are mostly from private planes. The number of low overflights has decreased now that the military is less active. No visitors to the Channel Islands have complained about noise due to low overflights. In my experience, low overflights are very occasional to rare.

If low overflights are infrequent, what is the largest source of disturbance?
SH: Large and small vessels.
JH and BW: Jet skiers
KF: Boaters – recreational and commercial fishing vessel are the greatest source of disturbance to wildlife within CINP. We currently have a problem with extremely bright lights on squid fishing boats. We also have a problem with kayakers startling nesting seabirds and marine mammals.

What types of animals are at risk from disturbance?
SH: The types of animals likely at risk include: CAGU, PECO, DCCO, BRCO, BRPE, SOSH, PFSH, XAMU, ASSP (60 seabird species use CINMS waters during their lifetime). Over 100,000 California Sea Lion, Stellar Sea Lion, Elephant Seals, Guadalupe Fur Seals and Harbor Seals have haul-outs on the western side of San Miguel Island. Humpback Whales, Blue Whales, and Fin Whales are also species of concern.
KF: We are probably most concerned with seals and sea lions. Most seal and sea lions have healthy populations, so noise due to overflights would likely impact individuals and not bring up population-level concerns. XAMU are a species of concern as well, but they're nocturnal, so the biggest threat to their population wouldn't be overflights. Cormorant colonies are also a concern.
SF: Harbor seals, California sea lions, BRPE, XAMU and cormorants are all a concern with regard to noise from low overflights.

Have you explored any other technologies to track vessels/planes?
JH and BW: We currently do not have any radar in place. The transponder system that tracks ships is not able to track small vessels or planes. We're thought about satellite imagery technology, but that's out of our price range.

If technology were installed to monitor overflights, when and where could it occur?
SH: The installation would have to occur sometime other than March 15-September. Solar power is available to all the islands within CINP.
SF: Some solar power is available on the islands. Installation would have to occur sometime other than in the spring.

Are there any existing programs that could observe overflights?
SH: NPS personnel on the islands; some islands open year round. Rangers, naturalists
KF: Island rangers are on the islands nearly 100% of the time in the summer, and about 50% of the time during other seasons. Santa Barbara is the only island that doesn't have staff present all the time – only about every other week throughout the year.
SF: NPS staff and researchers are the most likely candidates.
JH and BW: National Parks rangers have helped the sanctuary track tanker traffic on Ana Capa Island.

Has the sanctuary had any communication with the pilots?
SH: CINMS distributes information on regulated areas via e-mail. All pilots receive this information even if they have exemptions to fly within the sanctuary. There is an especially strong outreach effort to new charter pilots that are not familiar with sanctuary overflight recommendations.

x D. Technology Comparisons

	transponder scanning system	portable radar	telepresence	acoustic monitoring	Airport/FAA radar data	human
ly identify altitude of planes?	yes	yes w/ vertical setup(2)(5)	no	no	yes	no
here planes are in sky?	yes	yes	yes	no	yes	yes(1)
avel direction of planes?	yes(2)	yes(2)	yes	no	no	yes(1)
ake/model of planes?	no	no	yes(1)	no	yes	yes(1)
dividual aircraft?	no	no	yes(1)	no	not for VFR	yes(1)
	6 NM	12-16 mi.horiz., unlimited vert. (5)(6)	(5)(6)	frequency range (5)	depends on terrain	depend
re sky?	yes	no (30 deg. beam, can adjust)	no	yes	yes	yes(1)
ildlife disturbance?	no	no	yes	no	no	yes(1)
noise on ground?	no	no	no	yes	no	yes
te operator?	no	yes(6)	no	(6)	yes	n/a
ed for operation?	yes	yes	yes	yes	yes	yes
me data?	yes	yes	yes	yes	no	yes
a for later analysis?	yes with adapter & laptop	if screen filmed (5)	yes	yes	yes	yes
rmats	text log through serial port	visual only	video files	audio files	comma delimited	paper n
rts	(5)(A)	video (5)	audio/video	audio/logic	n/a	n/a
ata output?	yes	no	yes	yes	req. airport or faa help	n/a
ata analysis?	no	no	no	yes	yes, if in spreadsheet	no
	~$800 per unit (7)	~$8000 and up (7) (B)	~$5950 (7)	~$7420 (7)	administration costs	adminis
cld. batteries, except radar)	6"x4", 13.25 oz.(5)	189lbs (5)	18"x30"x48"/200lb(5)	50lb.(5)	n/a	n/a
?	no	yes(3)(4)	no	no(3)(4)	n/a	no (4)
peratures	-15C to +60F	-10C to +60C		-25C to +60C	n/a	n/a
ments	battery operated; can plug in (12v)	battery or plug into power	2 55amp battery/solar	battery	n/a	n/a
on batteries?	7hrs	8-10 hours (5)(B)	2 days (5)		n/a	n/a
logy in literature?	no	yes	yes	yes	no	
logy for overflight monitoring?	no	no	no	yes	no	
tocol developed?	no	for birds only	for wildlife only	yes	no	
le at all sanctuaries?	yes	no (site accessibility)	no	yes	no	no (diffe

e / conditions are good
several stations
other protection beyond weatherproofing -- e.g. buffering from wave 'noise'
e less reliable in heavy bad weather
make & manufacturer
setup
clude battery, accessory, or programming/data analysis cost
cable

(A)surecheck: proprietary 25 pin, adapted to 9pin serial; Monroy out to vga monitor only
(B)depends on model of radar (size of dish/ color screen or no) & type of battery;
Furuno 1510-3 lasts ~ 8 hours on 4 golf cart batteries.

Appendix E. List of possible technology vendors

Transponder Scanning System

Surecheck Aviation
542 South Pacific Street, Suite E101
San Marcos, CA 92078 USA
Phone: 888-340-8055
http://www.surecheck.net/
Contact: Jason Clemens, CEO

- Best-featured transponder scanner that we found -- expressed willingness to loan trial system

Monroy Aviation
P.O. Box 8217
Coral Springs, FL 33075 USA
Phone: 1-954-294-9006
http://www.monroyaero.com/detect.html
Contact: José Monroy

- Alternate vendor for transponder scanners

Radar

Furuno Marine Radar
Camas, Washington, U.S.A.
Phone: 1-360-834-9300
http://www.furuno.com/
Multiple local vendors

- Vendor for small, portable radar systems designed for marine applications; used by Burger (1997)

Rannoch Corporation
5252 Cherokee Avenue, Suite 400
Alexandria, VA 22312
Phone: 1-703-914-1430
Fax: 1-703-914-1454
http://www.rannoch.com

- Vendor for multilateration systems as well as conventional radar systems, including radar designed for small airports

Sensor Technologies & Systems
8900 East Chaparral Road
Scottsdale, AZ 85250
1-480-483-1997
www.sensor-tech.com
info@sensor-tech.com

- Vendor for radar systems, including radar systems designed for remote tracking of "intruding personnel, vehicles and low flying aircraft"

ABR, Inc.
P.O. Box 249

Forest Grove, OR 97116
1-503-359-7525
http://www.abrinc.com/

- Consulting group that has engineering several solutions for radar tracking of birds; see Cooper et al. (1991)

Acoustic Monitoring

Brüel & Kjær – North America
2815-A Colonnades Court
Norcross, Georgia 30071-1588
Phone: 1-770-209-6907
Toll Free: 800-332-2040
Fax: 770-448-3246
Toll Free Fax: 800-236-8351
http://www.bksv.com/
http://www.bkhome.com/bk_home.asp
Multiple local vendors

- Vendor for portable sound level analyzers, as well as integrated noise monitoring systems specifically designed for unattended, airport use; used by Dunholter (1989)

Larson and Davis
1681 West 820 North
Provo, Utah 84601
Toll-free USA: (888) BLUE 222 (258-3222)
PH: (801) 375-0177 Fax: (801) 375-0182
CustomerService@LarsonDavis.com
http://www.lardav.com/
Multiple local vendors

- Maker of acoustic noise monitoring equipment and sound level meters designed for environmental noise monitoring

Telepresence

SeeMore Wildlife Systems
127 E Bunnell
Homer, AK 99603
(907) 235-1492
sales@seemorewildlife.com
http://www.seemorewildlife.com

- Vendor for integrated camera systems designed for viewing wildlife; used for applications on Easter Egg Rock

Fuhrman Diversified, Inc.
2912 Bayport Blvd.
Seabrook, TX 77586-1501
(281) 474-1388
http://www.fieldcam.com/

- Vendor of remote video cameras designed for field observation applications; tested by McQuillen and Brewer (2000)

GenWac/Watec Cameras
60 Dutch Hill Road, Suite 6
Orangeburg, New York 10962, U.S.A.
Tel : (845)359-1490
Fax : (845)359-1391
E-mail: salesdep@genwac.com
http://www.wateccameras.com/genwac/
Multiple local vendors

- Manufacturer of closed circuit camera systems; used by Hughes and Shorrock (1998)

FAA/Airport data

Varies by airport – See list of Airport and FAA contacts in Appendices 5 and 6

Appendix F: Pilot Schools, FAA Contacts, and Flight Service Stations

Pilot Schools

A list of pilot schools by city and state is obtainable from the FAA at:
http://av-info.faa.gov/PilotSchool.asp

FAA contacts

California sanctuaries are located within the Western Pacific Region of the FAA.
General contact:
15000 Aviation Blvd., Lawndale, CA 90261
http://www.awp.faa.gov/
Specific contact for air traffic control and environmental issues:
Western Pacific Region, Air Traffic Division
Kathryn Higgins
Operations Specialist
(310) 725-6597
http://www.awp.faa.gov/atenviro/default.htm

OCNMS is located within the Northwest Mountain Region of the FAA.
General contact
Renton Regional Office
1601 Lind Avenue SW
Renton, WA 98055-4056
(425) 227-1028
http://www.nw.faa.gov/
Specific contact for air traffic control:
Pacific Northwest System Management Office
3101 Auburn Way South
Auburn, WA 98092
253.804.2900

VFR chart information

According to Kathryn Higgins, Operations specialist – FAA Western Regional Western Pacific Region, Air Traffic Division:
To make requests to include information on VFR charts:
Send a request to the FAA addressed to:
Western Terminal Service Area -- Air space
PO BOX 92007
Los Angeles 90007-2007
"Attention AWP-520"
Include mapped area on chart, request, and requesting agency information and contact information.

Flight Service Stations

Flight Service Stations provide weather, unpublished NOTAMS, and other information to general aviation pilots. They are typically the main point of contact for a general aviation pilot in flight.

FAA National list of Automated Flight Service Stations:
http://www.faa.gov/about/office_org/headquarters_offices/ato/afss/

Hawthorne Automated Flight Service Station. Hawthorne, Ca. Mike Lammes, Air Traffic Manager, (310) 970-0102. http://www.faa.gov/ats/hhrafss/index.htm

Oakland Automated International Flight Service Station. 1027 Grumman St. Oakland, Ca 94621. Norman Harris, Air Traffic Manager. (510) 273-6111.

Seattle Automated Flight Service Station. 6526 Ellis Avenue South. (206) 658-6600. Lee Daniel, Air Traffic Manager. http://www.nw.faa.gov/seaafss/

Appendix G. Aircraft Key

1. Circle aircraft type:

helicopter → go to 2 & 3

plane → go to 4

blimp

ultra-light

model airplane

other ____________

4. If plane: (circle one)

jet engines

propeller(s) → go to 5, 6, & 7

If helicopter:

2. # of rotors: (circle one)

1 top rotor

2 top rotors

3. landing gear: (circle one)

wheels

skids

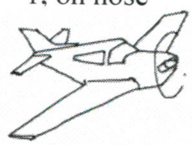
not visible (retracted)

If prop plane:

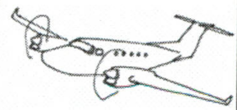
5. prop # and location: (circle one)

1, on top

1, on nose

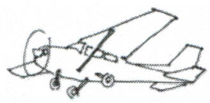


2, on wings

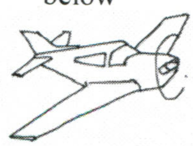


6. wing arrangement: (circle one)

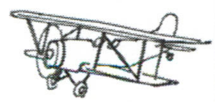
above



below

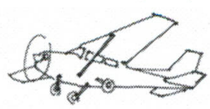


above & below (biplane)

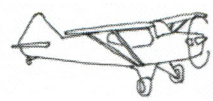


7. landing gear: (circle one)

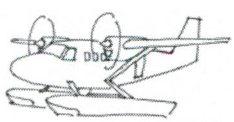
fixed wheels—3 front (tricycle)



fixed wheels—2 front, 1 tail



pontoons



not visible (retracted)