# Field report of the 2006/07 census of the Eastern North Pacific stock of gray whales

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## ABSTRACT
The southbound migration of the Eastern North Pacific stock of gray whales (*Eschrichtius robustus*) was documented by the National Marine Fisheries Service from 12 December 2006 to 22 February 2007. Research protocol was essentially identical to that used in previous surveys. This involved single observers independently searching for whales and recording data on environmental conditions and the time, location, count and direction of travel for each sighting. The counting system and observer performance were tested through paired, independent observational effort. In addition, in a nearby trailer, a team with two observers (one dedicated to searching, the other both searching and typing in data) rotated through 1.5 hr watches from 2 to 27 January. These counts by the Southwest Fisheries Science Center (SWFSC) will be compared with the standard effort (by the Alaska Fisheries Science Center) because the SWFSC will be conducting the gray whale census in the future. A fix-mounted, high-powered (25x) binocular provided an index (n = 110 pods; 19.7 hr) of the offshore distribution of migrating whales passing within the sighting range of the observers. The timing of the 2006/07 southbound migration seemed to be one week later than in previous years, with the median date close to 21 January instead of 15 January. Most (80%) of the sightings occurred in January, 17 % in February and only 3% in December. Counts of gray whales pods in fair to excellent visibility conditions totaled 1,770 pods during the 73 days (651.6 hr) of the standard census. This summary count compares favorably with similar counts from 2000/01 (1,684 pods in 599.4 hr) and 2001/02 (1,712 pods in 531.5 hr).

## INTRODUCTION
The National Marine Fisheries Service (NMFS) has conducted shore-based counts of the Eastern North Pacific stock of gray whales (*Eschrichtius robustus*) 22 times from 1967 to 2001 (Table 1) at Granite Canyon (or nearby at Yankee Point), 13km south of Carmel, in central California (Reilly, 1984; Buckland and Breiwick, 2002). Convenient access to the Granite Canyon research station (owned by NOAA but operated by the State of California Department of Fish and Game) and the narrowness of the whales' migratory corridor in this area (Shelden and Laake, 2002) permitted an efficient counting process at this site. All counts were during the 2 month southbound migration rather than the protracted 3 month northbound migration (Pike, 1962). The routine nature of these counts and the consistency in research protocol lend themselves to inter-annual trend analyses. For example, Rugh *et al.* (2005) showed there has been an increase of approximately 2% per annum through 2001/02.

The primary objective of the study in 2006/07 was to provide another in the series of abundance estimates such that trend analysis could be continued. These estimates may provide the first documentation of a stock of large whales approaching carrying capacity (Wade and DeMaster, 1998). An additional incentive to conduct this season's study was to assess the abundance after two years (1999 and 2000) in which unusually high counts of dead gray whales had been reported (LeBoeuf *et al.*, 2000; Gulland *et al.*, 2005) and after two censuses (2000/01 and 2001/02) in which abundance estimates were well below the expected trajectory (Rugh *et al.*, 2005).

**METHODS**

Systematic counts of gray whales were conducted from 12 December 2006 to 22 February 2007, covering virtually the entire southbound migration past the Granite Canyon research station. Observation sheds provided a writing platform with some protection from the elements, and they helped observers concentrate on the viewing area. Average eye height above sea level was 22.5m. Although the field of view covered >150°, observers generally searched through an arc of only 40-50° near the standard azimuth, which is a line perpendicular to the coastline (at 241° magnetic) that intersects the survey site.

Three 3 hour standard-watch shifts covered the 9 daylight hours from 0730 to 1630. Observers were rotated to keep a balance of effort in each of the three shifts. Nine people participated in the shore-based counts conducted by NMML. All but two of these observers had a few or many years of previous experience counting gray whales at Granite Canyon.

Standard-watch procedures were the same as those used in previous surveys (Rugh *et al.*, 1990; 1993). Each observer operated independently and hand-recorded entries onto a data form. When a gray whale pod entered the viewing area, the time, horizontal bearing, and vertical angle were recorded as the "north sighting." Magnetic compasses in Fujinon 7x50 binoculars provided the horizontal bearings (±2°), and 14 reticle marks in the binoculars provided vertical angles relative to the horizon (detailed in Rugh *et al.*, 1993; Kinzey and Gerrodette, 2001). Observers tried to keep track of each pod traveling through the viewing area. Observers used a table based on average swimming speeds and sighting locations to predict the time and vertical angle where a pod would cross the standard azimuth. The time, horizontal bearing, and vertical angle were recorded a second time (the "south sighting") as close to the standard azimuth as possible, and a pod-size estimate was recorded along with any unusual behaviors, the presence of a calf, and the number of times the pod was seen as it moved through the viewing area. Observers also recorded start and end times of systematic search effort, environmental changes, presence of vessels (optional) and other cetacean sightings. Entries included visibility (subjectively categorized from 1 to 6 for excellent to useless), wind direction and sea state (Beaufort scale).

In addition to the primary watch (generally at the "South Shed"), a second, independent watch was conducted (at the "North Shed") one to three times daily from 6 January to 1 February 2007. The field of view and altitude of the two sheds were nearly identical. This provided paired, independent sighting records, allowing for comparisons between observers and an estimation of the number of whales missed within the viewing area (Rugh *et al*,. 1993).

Offshore distribution of whale sightings was documented through a fix-mounted, 25-powered binocular (Rugh *et al.*, 2002). From 8-31 January 2007, there were 26 watches (45 minutes each). Aerial survey results have shown that only 1.28% of the whale population travels seaward of the viewing range of shore-based observers, approximately 3nm offshore (Shelden and Laake, 2002). Therefore, no correction, other than for probability of detection by distance, is necessary for whales passing beyond the viewing range.

Population abundance calculations (in a later report) will follow the analytical procedures described in Hobbs *et al.* (2004). These methods account for: 1) whales passing during periods when there is no observational effort (before and after the census season, at night or when visibility is poor); 2) whales missed within the viewing range during on-effort periods; 3) differential sightability by observer, pod size, distance offshore and various environmental conditions; 4) errors in pod-size estimation; 5) covariance within the corrections because of variable sightability by pod size and 6) differential diel travel rates of whales.

## RESULTS

### Sample size

The 2006/07 gray whale census was conducted for 73 days from 12 December 2006 to 22 February 2007 (Fig. 1), a period similar to previous years (Table 1). Observers in the primary (South) shed recorded 1,861 pods of gray whales, of which 1,770 were seen during excellent to fair conditions (visibilities 1-4). Watches were maintained for a total of 651.6 hr on the primary watch (542.3 in visibilities 1-4), 111.7 hr on the secondary watch (during paired, independent counting efforts, n = 758 pods) and 19.7 hr on the fixed, high-powered binoculars (n = 110 pods).

### Visibility

Of the six subjective categories of visibility, little time was spent in the best (category 1; 2.0 hr) and worst (category 6; 9.3 hr) conditions, but intermediate categories 2-5 were well represented, with 81.2, 218.3, 240.4 and 100.5 hr each, respectively (Table 2). Sighting rates indicated a linear drop from good to poor conditions (Fig. 2) unlike other years when the only apparent drop in sighting rates was in categories 5 and 6 (Hobbs *et al*., 2004; Rugh *et al.*, 2005).

### Migratory timing

The 2006/07 study included almost the entire southbound migration of gray whales because sighting rates were very low (<1/hr) for the first 16 days of the study (until 27 December), and by 15 February, sighting rates dropped below 1/hr (Fig. 1). Typical of most southbound migrations of gray whales observed from Granite Canyon (Table 1), sighting rates rose from late December until mid-January and then gradually declined until mid-February, approximating a normal distribution. However, the migration seemed to be later than usual in 2006/07. The mean sighting date in 2006/07 was 21 January (day 52, with day 1 = 1 December), approximately a week later than the expected mean date of 15 January (Rugh *et al.*, 2001).

**DISCUSSION**

The number of gray whale pods seen in 2006/07 was similar to counts recorded in 2000/01 and 2001/02 but lower than in previous years (Table 1). There was a 2.6% per annum increase in abundance from 1967/68 to 1997/98 (Rugh *et al.*, 2005), but then abundance dropped. Recorded rates of >270 dead gray whales seen in 1999 (LeBoeuf *et al.*, 2000; Gulland *et al.*, 2005) and >300 in 2000 (Gulland *et al.*, 2005) were much higher than the average rates of 41/yr from 1995-98 (Gulland *et al.*, 2005) indicating there may have been a large die-off in this population.

It does not seem that observer experience, shifts in the migratory corridor, or visibility can adequately explain why abundance estimates have been lower since 1997/98. However, we have not yet fully tested the theory that inconsistent proportions of the population migrate as far south as Granite Canyon. In most years, the timing of the gray whale migration has been phenomenally regular (Rugh *et al.*, 2001). Unexpectedly low encounter rates occurred in 1992/93, yet that season was followed by several seasons with much higher estimates (Table 1). One of the primary explanations for the low abundance estimate in 1992/93 was that various proportions of the gray whale population remain north of Granite Canyon each year, and in 1992/93 more whales than usual stayed north of this site (Laake *et al.*, 1994). Perhaps in 2000/01, 2001/02 and 2006/07, as in 1992/93, many whales did not migrate as far south as Granite Canyon.

A slowing in the recorded rise in abundance from 1967/68 to 1997/98 has been anticipated (Reilly, 1992; Wade, 1997); but until 2000/01, there was only a suggestion of density-dependence beginning to occur (Wade and DeMaster, 1998). If the most recent abundance estimates are representative, it could be the first indication this stock of whales has reached the carrying capacity of its environment. We may anticipate in the future that abundance will fluctuate as this population approaches equilibrium and adjusts to environmental limitations.

Responsibility for conducting the southbound gray whale census is in the process of being transferred to the Southwest Fisheries Science Center (SWFSC). Concurrent with this shift, some modifications to the standard watch procedures described above have been proposed. These suggested changes include: 1) the use of two-person observation teams, comprised of both a "dedicated observer" and a "data recorder", to aid in locating and following pods, and 2) the utilization of software (Gray Whale©, Robert Holland, SWFSC) to facilitate pod tracking. While these modifications are intended to increase the accuracy and efficiency of current protocols, any biases introduced into the dataset by these changes must be assessed prior to integration into the standard methodology to ensure that continuity with the long-term dataset is preserved for inter-annual trend analysis. In order to identify potential biases, two-person observer teams using the Gray Whale© software conducted independent counts simultaneous with the standard watches between 2 January and 3 February 2007. The two independent datasets generated during this period are currently being compared following the methods detailed in Rugh *et al.* (1993), and the impact of the suggested changes on data quality will be evaluated. If this assessment indicates that the proposed modifications represent improvements to the current watch protocols, these changes can be incorporated into the methodology for future field seasons.

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Table 1. Duration of survey effort conducted by NMFS during counts of the southbound migration of gray whales at Granite Canyon, California. Uncorrected counts of whale pods (without hours of effort indicated) and the published abundance estimates are shown. Although abundance estimates presented here used the same method each year, standard errors since 1995 were adjusted to incorporate sources of variance not documented in previous years.

| Start dates | | End dates | | Count | Abundance | SE | Source |
|---|---|---|---|---|---|---|---|
| 1967 | 18 Dec | 1968 | 3 Feb | 903 | 13,776 | 1,082 | 1 |
| 1968 | 10 Dec | 1969 | 6 Feb | 1,079 | 12,869 | 708 | 1 |
| 1969 | 8 Dec | 1970 | 8 Feb | 1,245 | 13,431 | 758 | 1 |
| 1970 | 9 Dec | 1971 | 12 Feb | 1,458 | 11,416 | 590 | 1 |
| 1971 | 18 Dec | 1972 | 7 Feb | 857 | 10,406 | 614 | 1 |
| 1972 | 16 Dec | 1973 | 16 Feb | 1,539 | 16,098 | 834 | 1 |
| 1973 | 14 Dec | 1974 | 8 Feb | 1,496 | 15,960 | 872 | 1 |
| 1974 | 10 Dec | 1975 | 7 Feb | 1,508 | 13,812 | 781 | 1 |
| 1975 | 10 Dec | 1976 | 3 Feb | 1,187 | 15,481 | 930 | 1 |
| 1976 | 10 Dec | 1977 | 6 Feb | 1,991 | 16,317 | 818 | 1 |
| 1977 | 10 Dec | 1978 | 5 Feb | 657 | 17,996 | 1,249 | 1 |
| 1978 | 10 Dec | 1979 | 8 Feb | 1,730 | 13,971 | 753 | 1 |
| 1979 | 10 Dec | 1980 | 6 Feb | 1,451 | 17,447 | 984 | 1 |
| 1984 | 27 Dec | 1985 | 31 Jan | 1,756 | 22,862 | 1,379 | 1 |
| 1985 | 10 Dec | 1986 | 7 Feb | 1,796 | 21,444 | 1,120 | 1 |
| 1987 | 10 Dec | 1988 | 7 Feb | 2,404 | 22,250 | 1,115 | 1 |
| 1992 | 10 Dec | 1993 | 7 Feb | 1,180 | 18,844 | 1,190 | 2 |
| 1993 | 10 Dec | 1994 | 18 Feb | 1,864 | 24,638 | 1,475 | 2 |
| 1995 | 13 Dec | 1996 | 23 Feb | 2,151 | 24,065 | 1,393 | 3 |
| 1997 | 13 Dec | 1998 | 24 Feb | 2,853 | 29,758 | 3,122 | 4 |
| 2000 | 13 Dec | 2001 | 5 Mar | 1,684 | 19,448 | 1,882 | 4 |
| 2001 | 12 Dec | 2002 | 5 Mar | 1,712 | 18,178 | 1,780 | 4 |
| 2006 | 12 Dec | 2007 | 22 Feb | 1,770 | --- | --- | 5 |

Sources:
1 = Buckland and Breiwick (2002)
2 = Laake *et al.* (1994)
3 = Hobbs *et al.* (1996)
4 = Rugh *et al.* (2005)
5 = current document

Table 2. Rates of sightings of gray whale pods (encounter rates) as a function of visibility code.

| Visibilities | Codes | Hours of effort | Number of pods | Encounter rates | SE |
|---|---|---|---|---|---|
| Excellent | 1 | 3.0 | 8 | 2.67 | 2.40 |
| Very Good | 2 | 80.2 | 397 | 4.95 | 0.54 |
| Good | 3 | 218.8 | 746 | 3.41 | 0.31 |
| Fair | 4 | 240.4 | 619 | 2.58 | 0.24 |
| Poor | 5 | 100.0 | 90 | 0.90 | 0.15 |
| Useless | 6 | 9.3 | 1 | 0.11 | 0.11 |
| | | | | | |
| All Effort | 1-6 | 651.6 | 1,861 | 2.86 | 0.16 |
| Usable Effort | 1-4 | 542.3 | 1,770 | 3.26 | 0.19 |

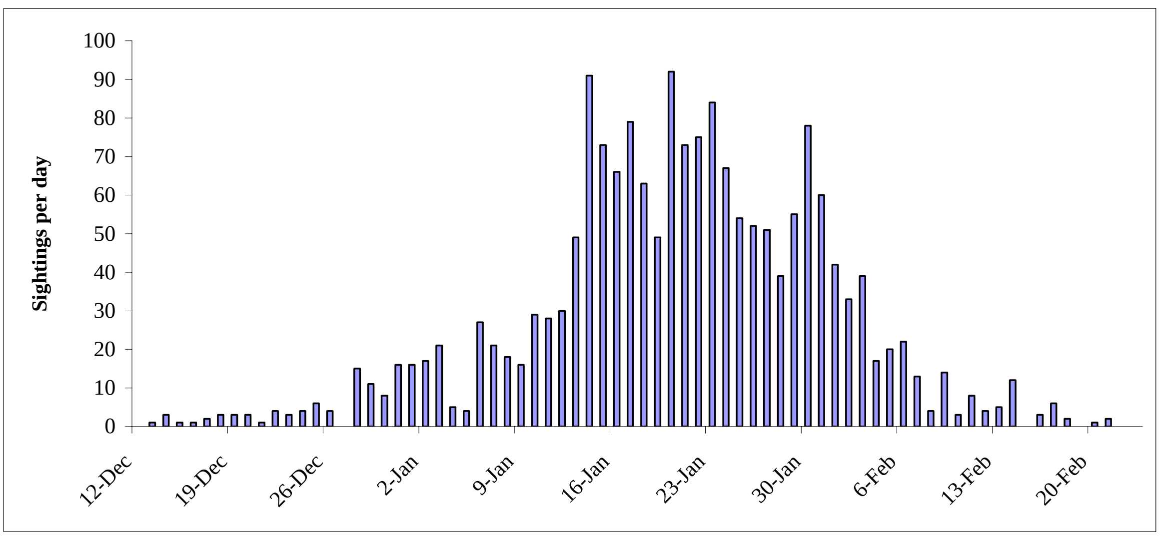


Figure 1. Gray whale sightings as a function of date during the southbound migration past Granite Canyon, California, in 2006/07.

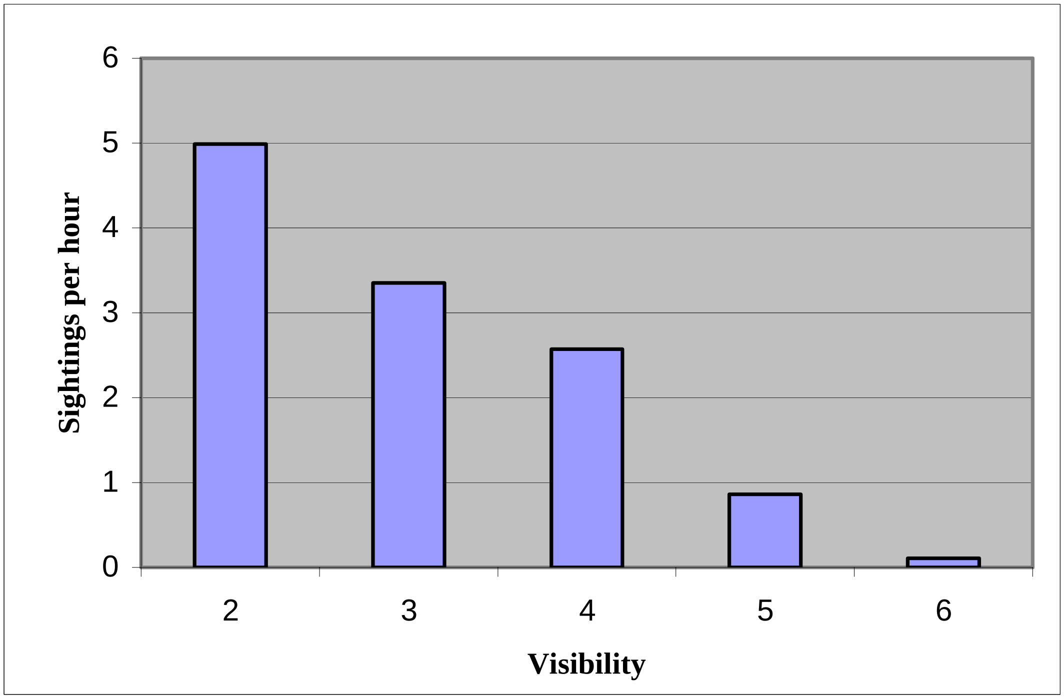


Figure 2. Sighting rates of gray whale pods per hour as a function of visibility categories graded from very good [= 2] to useless [= 6]. Insufficient time was spent in excellent visibility [= 1] for it to be included here.