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U.S. DEPARTMENT OF COMMERCE
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ABSTRACT

Accurate catch estimates are necessary for successful fishery management. Catch weights may be affected by fish bleeding; a practice fishermen use to ensure product quality. We conducted field experiments during July 2002 and July 2003 in the Gulf of Alaska to estimate the change in fish weight due to blood loss for sablefish. Fish weights were compared before and after bleeding. Sablefish lost more weight when bled without seawater than when immersed in flowing seawater. Sablefish lost more weight when carefully brought aboard than when gaffed aboard (bled without flowing seawater). Gaffed sablefish lost weight even when not intentionally bled because of blood loss at the gaff wound. The product recovery rate (PRR) currently applied by fishery managers to estimate catch weight for bled sablefish (2.0%) slightly overestimates "blood loss" for fish gaffed aboard (1.7%). The PRR applied by fishery managers for unbled sablefish (0.0%) underestimates "blood loss" for fish gaffed aboard (1.0%). Estimating the actual change in weight due to blood loss for a commercial fishing trip is difficult because it requires accounting for storage methods and handling practices.

CONTENTS

INTRODUCTION

Some fishermen bleed sablefish (*Anoplopoma fimbria*) to ensure product quality. Fish are bled by breaking or cutting gill rakers, then allowing the fish to bleed. The amount of blood lost likely is affected by several factors, some under the fishermen's control and others not. Storage methods (ice or refrigerated seawater) and handling practices (gaffing, hook removal devices, and soak time) affect blood loss.

The National Marine Fisheries Service (NMFS) applies a product recovery rate (PRR) for round, bled sablefish of 0.98 (NMFS product code 03) (Low et al. 1989). The PRR is used to estimate the live weight of landed bled sablefish by dividing the landed weight by 0.98. The current PRR dates back to the early 1980s and it is not known whether the figure was verified for sablefish[1]. The PRR is important to fishery managers for tracking fishery removals and to fishery scientists for assessing stock status. For example, average reported longline catch during 1999-2003 was 12,942 t; an absolute error of 0.01 in the PRR would result in a catch estimation error of 129 t. The PRR also is important to fishermen because it affects the amount subtracted from the fishermen's individual quota with each delivery of bled sablefish. For example, the effect of the 0.98 PRR is that for every 10,000 kg of bled sablefish delivered, 10,200 kg is deducted from that fisherman's individual quota.

Estimating an accurate PRR is challenging because several variables need testing. An experiment designed to estimate the actual PRR for sablefish would need to address storage methods and handling practices. Our approach was to estimate the change in weight due to blood

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loss expected for four treatments under controlled conditions. This approach both reduced the number of treatments and fit the length of field time available for this experiment. The study was a cooperative project between the Alaska Longline Fishermen's Association and the NMFS Auke Bay Laboratory. The data were collected during the 2002 and 2003 NMFS sablefish longline surveys.

MATERIALS AND METHODS

The experiments were conducted on 25-26 July 2002 and 25-26 July 2003, on the upper continental slope near Yakutat Bay in the Gulf of Alaska. The chartered U.S. longline vessels, the F/V *Alaskan Leader* (overall length of 46 m) in 2002 and the F/V *Ocean Prowler* (overall length of 47 m) in 2003, deployed baited longline gear. Size 13/0 Mustad circle hooks were hand baited with chopped squid (*Illex* spp.). Three sets of 2,672 hooks each were deployed each day for a total of 6 sets during the 2-day experiment. Setting started at 0630 hours and retrieval started at 0930 hours. Soak time ranged from 3 to 8 hours.

In 2002, fish were carefully released from the hook, dropped into a net, and then brought aboard the vessel to obtain an initial live weight. Only active fish in good condition were chosen. Fish were weighed before bleeding in a closed plastic pipe to still the fish. Fish were weighed with a Marel M1100 motion compensated marine scale. Scale accuracy was ± 2.5 g. The scale was calibrated at the beginning of each set retrieval. The closed plastic pipe was 15.2 cm diameter and 45.7 cm long and constructed of PVC. Neoprene fabric covered one end. The pipe rested in a cradle during weighing. After weighing, fish were marked with a unique tag and the two most posterior gill rakers on the fish's right side were cut. Two treatments were carried out to test how handling practices affect blood loss. In the first treatment, fish were placed in a tank filled with flowing seawater to bleed. In the second treatment, fish were placed in a tub without any water to bleed. Slime was wiped off fish in the latter sample before weighing post-bleeding. Fish in flowing seawater did not accumulate slime on their skin and were not wiped. Clotted blood in the gill rakers was left in place.

In 2003, fish were gaffed aboard the vessel rather than carefully releasing them from the hook as in 2002. Gaffing is the normal method of bringing fish aboard during longline fishing. Only active fish in good condition (before gaffing) were chosen. Fish were weighed immediately after gaffing in the closed plastic pipe. After weighing, fish were marked with a unique tag. Two treatments were carried out to test how handling practices affect blood loss. In the first treatment, the two most posterior gill rakers on the fish's right side were cut. In the second treatment, the gill rakers were not cut. Fish in both treatments were placed in a tub without seawater to bleed. Slime was wiped off fish before weighing post-bleeding. Clotted blood in the gill rakers was left in place. The experimental treatments during 2002 and 2003 are summarized in Figure 1.

Sampled sablefish were chosen by chance. After weighing one fish, the next fish retrieved from the longline was chosen for processing. This selection scheme resulted in sampling approximately one in every twelve fish. The ratio of the post-bleeding and live weight was computed for each sampled sablefish. For example, if the live weight was 3.5 kg and the post-bleeding weight was 3.45 kg, then the ratio is 0.986. The distributions of ratios for sablefish bled without flowing seawater were skewed and not normal. The transformations of log, square root, reciprocal, and arcsine-square root did not change the distributions from skewed to normal. The median may be preferred to the mean for expressing central tendency for skewed populations and therefore, the median ratio was computed for each treatment and a confidence interval for the median was estimated (Zar 1984). The bootstrap method (Efron and Tibshirani 1986) also was applied to estimate the confidence interval and gave similar results to the method described in Zar (1984).

RESULTS

The total sample size was 611 sablefish (Table 1). Sample size by treatment ranged from 74 to 252 fish. Average fish size was 3.7 kg round weight (Figure 2). Sablefish bled in flowing seawater frequently gained weight (Figure 3A), whereas all but one sablefish bled without seawater weighed less after bleeding (Figures 3B-D). For sablefish carefully brought aboard and with gills cut, the median ratio was 0.984 for sablefish bled in flowing seawater and 0.980 for sablefish bled without seawater (Table 1). These medians imply that blood loss typically is 1.6% for sablefish bled in flowing seawater and 2% for sablefish bled without seawater. For sablefish gaffed aboard and bled without flowing seawater, the median ratio was 0.983 for sablefish with gills cut and 0.990 for sablefish with gills left intact. These medians imply that blood loss typically is 1.7% for gills cut and 1.0% for gills left intact.

DISCUSSION

Weight Measurements

The change in weight due to blood loss was measured precisely. The 95% confidence intervals for the medians were narrow. For example the interval was 0.982–0.985 for sablefish bled in flowing seawater, a range of only 0.003. The range of confidence intervals was narrow for all treatments, only 0.003-0.007.

Sablefish lost more weight when bled without seawater (2.0%) than with flowing seawater (1.6%) (gills cut, fish carefully brought aboard). The hydrostatic pressure of the water in the bleeding tank may act on the severed blood vessels to reduce blood volume loss. Alternatively, the heart, which continues to pump after the gill rakers are cut, may siphon seawater into the fish's circulatory system, replacing the blood with seawater and possibly increasing circulatory system fluid volume. Finally, some water may have remained in the stomach of fish bled in flowing seawater, even though efforts were made to evacuate all water from the stomach prior to the post-bleeding weighing.

Sablefish lost more weight when carefully brought aboard (2.0%) than when gaffed aboard (1.7%) (gills cut, bled without flowing seawater). Fishermen gaff the fish's head, usually stunning the fish. Blood loss is reduced, probably because of the blow. Sablefish lost weight even when not intentionally bled (1.0%), probably because of blood loss at the gaff wound (gills left intact, bled without flowing seawater).

Accuracy of Currently Applied PRR

The product recovery rate (PRR) currently applied by fishery managers to estimate catch weight for bled sablefish slightly overestimates blood loss for fish gaffed aboard. The National Marine Fisheries Service applies an adjustment to landings of bled sablefish that implies blood loss is 2% of body weight (PRR = 0.98, bled fish, product code 03). Gaffing fish is the normal method of bringing fish aboard during longline fishing. We found that blood loss is slightly less, 1.7% of body weight for bled sablefish that are gaffed aboard. The implied PRR is 0.983 rather than the current 0.98.

The PRR applied by fishery managers for unbled sablefish underestimates blood loss for fish gaffed aboard. No adjustment currently is applied for sablefish not deliberately bled (PRR = 1.0, whole fish, product code 01) (Low et al. 1989); however, we found that blood loss is 1.0% of body weight for sablefish that are gaffed aboard. The implied PRR is 0.99 rather than the current 1.0.

Historical catch estimates represent the weight of sablefish after gaffing, rather than live weight. Most sablefish were gaffed aboard, classified as whole fish, and the PRR of 1.0 was applied. Historical catches underestimate the live weight of the catch by 1% because the correct PRR is 0.99. Fishery catches as well as catches from sablefish longline surveys are affected. For example, average reported longline catch during 1999-2003 was 12,942 t; estimated live weight is 13,073 t (=12,942 × 1.0 / 0.99). Thus the live weight of the catch was underestimated by 131 t.

Ability to Measure and Apply an Accurate PRR

Common handling practices and storage methods affect blood loss. On sets left to soak overnight, a common practice in the fishery, some fish are dead, some are in poor condition, and some are active. Blood loss from fish retrieved dead or in poor condition, although not measured, likely is negligible and would reduce average blood loss accordingly. Conversely, we found fish bled in flowing seawater frequently gained weight. Therefore, blood loss may be different for fish stored in refrigerated seawater compared to fish stored on ice.

Measuring and applying an accurate PRR is difficult given the variety of conditions existing in the fishery. Measuring an accurate PRR requires further studies of the effects of storage methods (ice or refrigerated seawater) and handling practices (gaffing, hook removal devices, and soak time), which would be time-consuming to complete. Applying the results of these studies would be difficult because the storage methods and handling practices would need quantification for each trip (e.g. percentage of fish retrieved dead). Accurately accounting for these factors would be complex and difficult, especially because blood loss is low.

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Table 1.-- Median blood loss (ratio of post-bleeding and live weights) and 95% confidence intervals for median by treatment.

Treatment	Median	Lower 95% confidence interval	Upper 95% confidence interval	Sample size
Carefully released from hook, gills cut, bled in flowing seawater	0.984	0.982	0.985	252
Carefully released from hook, gills cut, bled without flowing seawater	0.980	0.976	0.983	74
Gaffed aboard, gills cut, bled in tub without flowing seawater	0.983	0.981	0.985	128
Gaffed, gills left intact, bled in tub without flowing seawater	0.990	0.988	0.991	157

Figure 1. -- Flow diagram of experimental treatments.

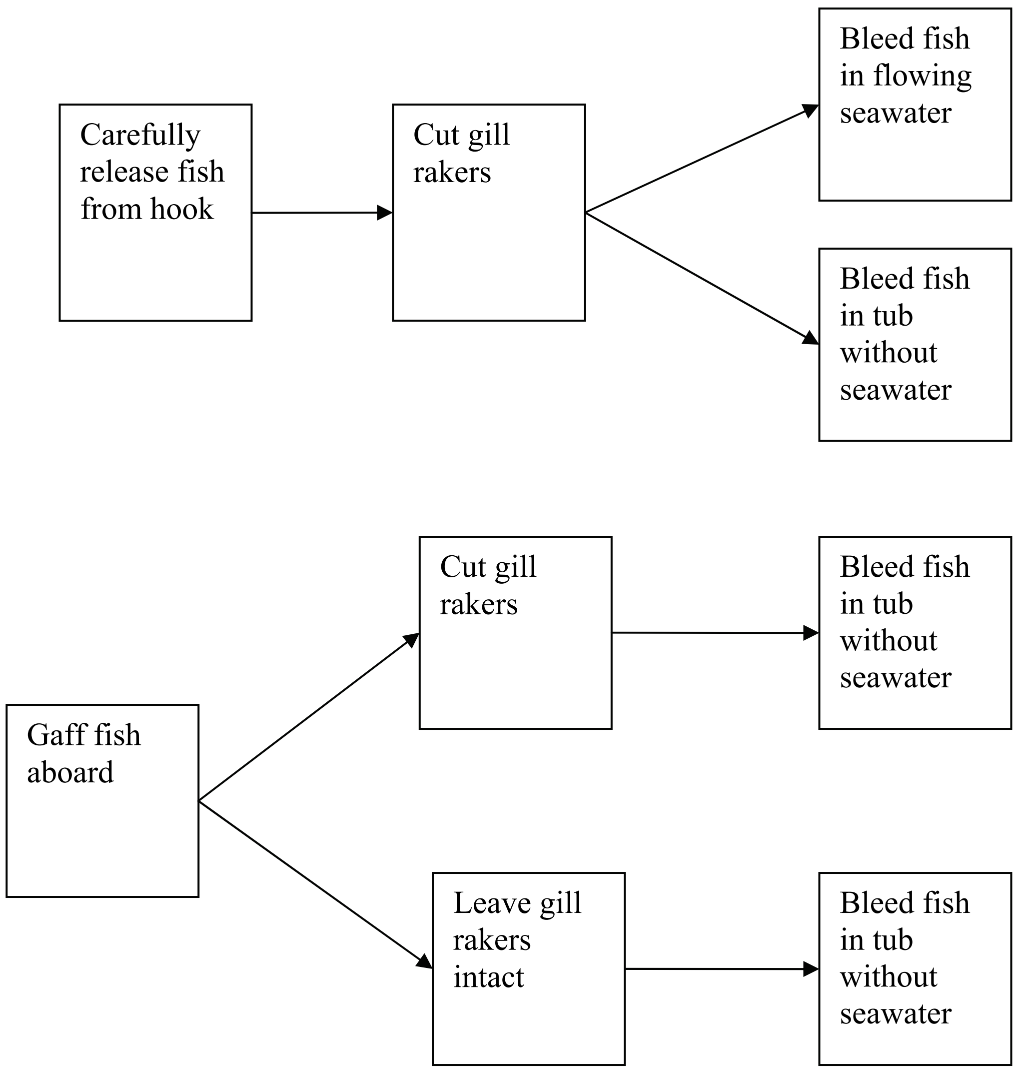


Figure 2.--Size distribution (live weight in kilograms, rounded to the nearest kilogram) of sablefish sampled in the bleeding study.

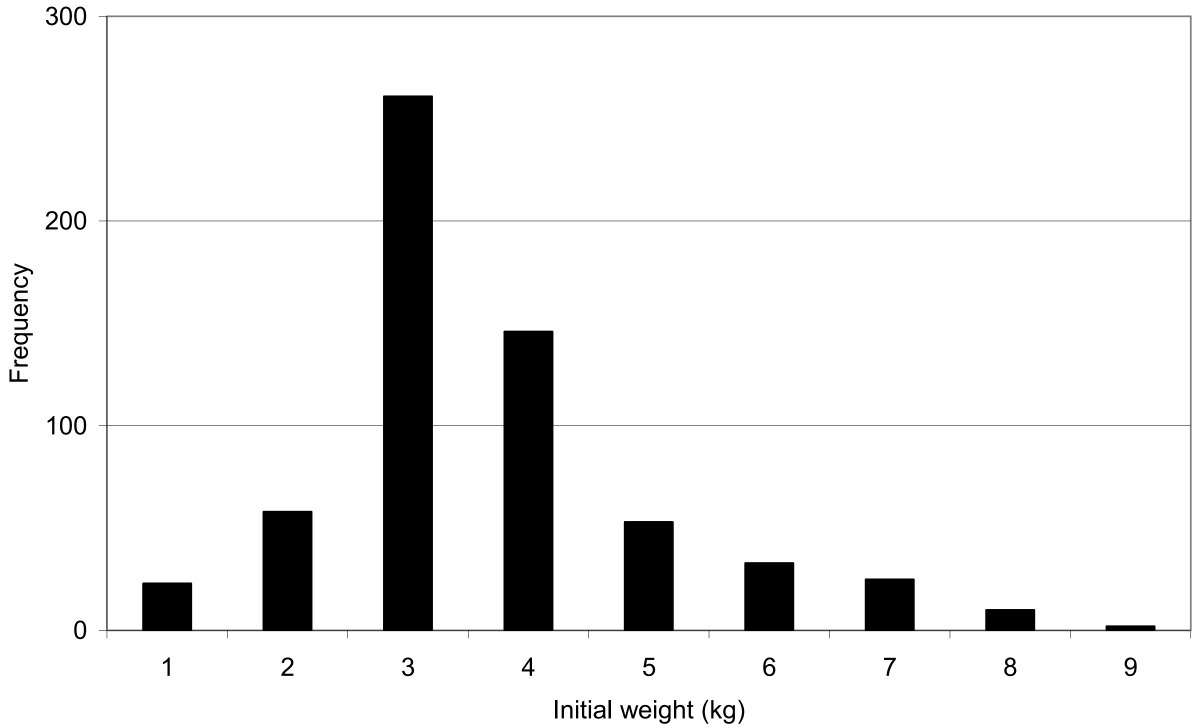
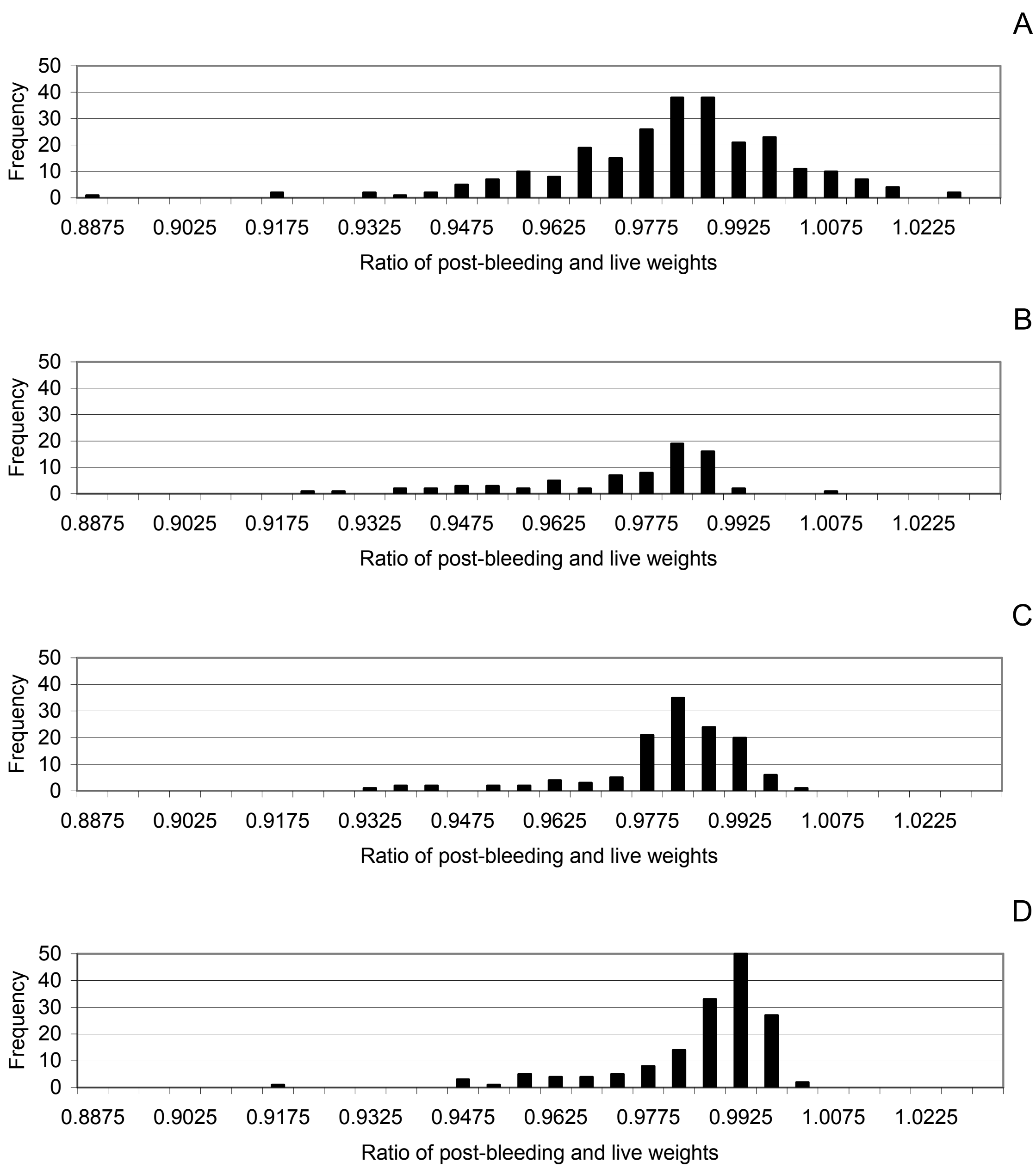


Figure 3.--Frequency distributions of post-bleeding weight to live weight of sablefish bled without flowing seawater. A. Carefully released from hook, gills cut, bled in flowing seawater. B. Carefully released from hook, gills cut, bled in tub without seawater. C. Gaffed aboard, gills cut, bled in tub without seawater. D. Gaffed aboard, gills left intact, bled in tub without seawater.



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