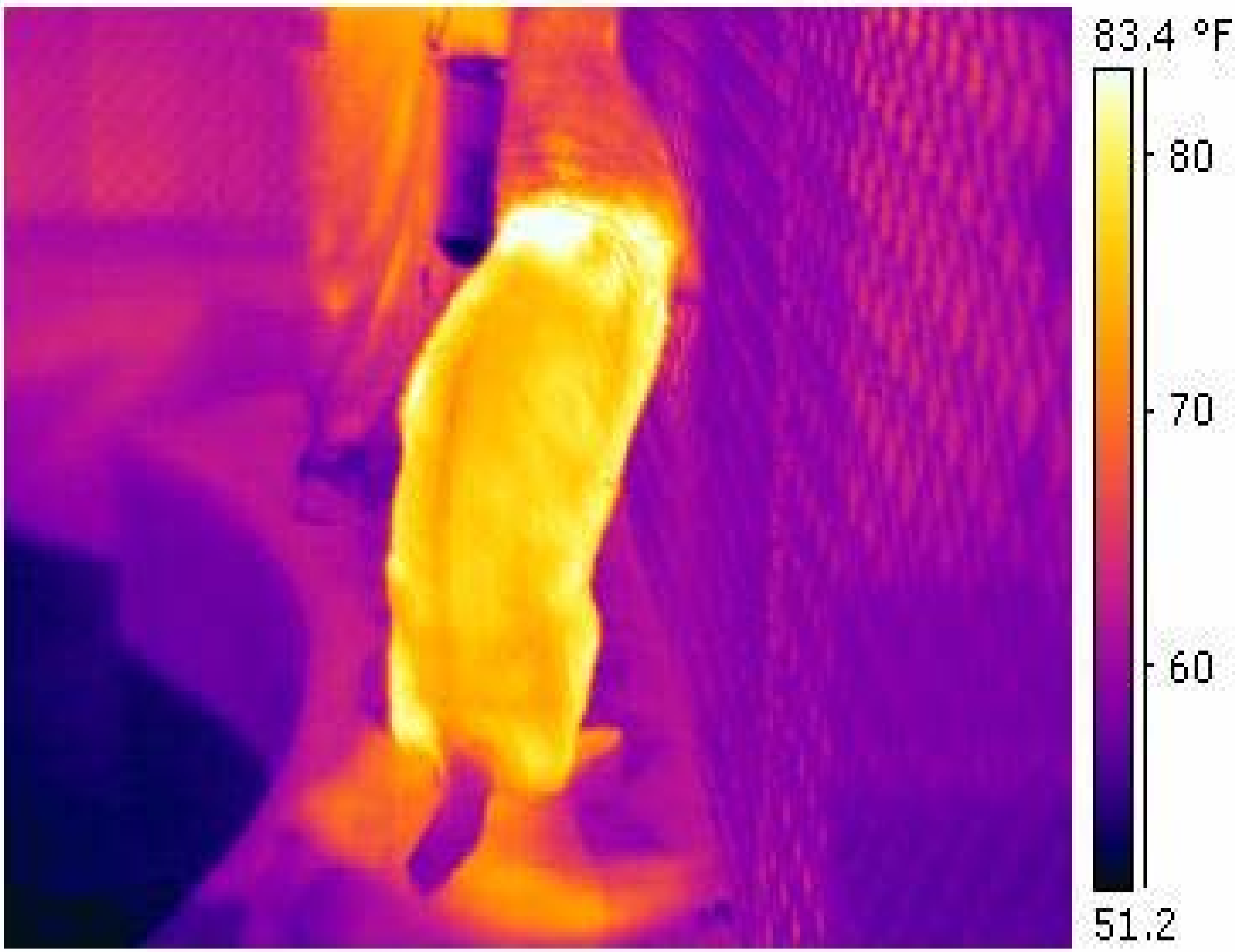
# Oiled Wildlife Infrared Camera
# SSEP Study P0475035

**Prepared by: David A. Jessup, Senior Wildlife Veterinarian**



**On the Cover:** Infrared photo of a southern sea otter four hours after washing three quarters of the animal (from the forearms down) with detergent and water. The purple and blue colors of the neck and head represent normal thermal image where heat is conserved by the fur's insulating properties, the orange to yellow to white coloration shows heat radiating from the washed portions of the body as a result of the fur's loss of heat conservation properties. The temperature scale to the right allows some appreciation of the differences, but software also allows this to be fairly precisely quantified and followed through time as the animal's fur recovers. IR images taken with a ThermaCAM S65 by Sharon Toy-Choutka taken with "iron tone" palate.

**Report outline:**

Summary
Introduction
FLIR ThermaCAM S65
Use in "Physiology of Washing Sea Otters"
Use in monitoring post-operative recovery and restoration of waterproofing in seabirds
Discussion

## Summary:

The primary proximate cause of mortality in marine birds and sea otters when they become fouled by petroleum and other oils is the loss of water repellency of feathers and fur. This loss of water repellency results in rapid loss of body heat in some cases, or chronic loss of body heat, such that the animal cannot maintain core body temperature. The loss of water repellency may also reduce the bird's or otter's ability to swim and forage normally and, together with the metabolic challenge of plunging core body temperature, result in depletion of energy reserves (hypoglycemia and starvation), resulting in multiple organ system failure, coma and death. Sometimes fur or feather water repellency is not readily appreciated by the human eye or with regular photography. Infrared thermal imaging recognizes heat rather than visible spectrum light and offers a means to measure and compare heat loss in animals affected by oil or that are recovering from washing to remove oil from their fur or feathers. The following report documents efforts by the California Department of Fish and Game – Marine Wildlife Veterinary Care and Research Center and the University of California-Davis, Oiled Wildlife Care Network to utilize and test a FLIR model S65 ThermaCAM infrared thermography camera under several research and oil spill response conditions.

## Introduction

Light waves in the visible spectrum are detectable by the human eye and can be recorded on photosensitive materials like photographic silver halide emulsions. Almost 200 years ago scientists like Herschel recognized that light in the lower wavelengths transferred more heat energy (ThermaCAM S65 Operating Manual). Wavelengths lower than visible red (thus the name infrared) are the most efficient at transferring heat and advances in the development of detection devices have resulted in the development of infrared cameras. Infrared cameras image and measure the emitted infrared radiation (heat) from an object. That radiation is a function of the objects surface temperature making it possible for the camera to calculate and display this temperature. Although the radiation measured by the camera depends primarily on the temperature, it is also a function of emissivity, that is the sum of the radiation originating from the object and that of the immediate surroundings reflected off the object.

Heat loss due to disturbance of feather or fur insulating properties has a significant negative effect on survival of birds and mammals exposed to oil(s) and other substances with surfactant or fouling properties. Detecting where and to what degree fur or feather insulating properties may be disturbed is integral to understanding the effects of oil on wildlife. Similarly, being able to track the return of water repellency could greatly assist those providing care for oiled wildlife in determining the effects of their treatments and in predicting when recovery is proceeding in a positive direction.

Oil and water have very different light emission properties. So, infrared thermography should be able to distinguish oil on the surface of water even if both oil and water are at the same temperature.

In 2006 CDFG-OSPR purchased a FLIR ThermaCam S65 camera to: 1) assist with a separate Scientific Study and Evaluation Program (SSEP) project P0375032 "Investigating the Thermoregulatory Physiology of Washing Sea Otters," 2) assist the Oiled Wildlife Care Network in both research and response efforts to determine how to recognize and reduce heat loss in oil-affected birds and 3) to attempt to determine how this technology might be used in response situations. Herein we report on the uses of that FLIR ThermaCam S65 camera from summer 2006 through fall 2009, as well as significant progress made on goal 1, some progress on goal 2, and relatively little progress on goal 3.

## FLIR ThermaCAM S65

The S65 Thermacam is one of a number of thermal imaging systems manufactured by FLIR Systems, 16 Esquire Rd., North Billcirca, MA 01862. The S65 can make accurate measurements from -40 to 1500C. It can distinguish temperature variations as small as .06 C. The S65 auto focus and auto range features allow crisp high-resolution thermal images. Each image has 78,000 pixels, the temperature of which can be measured. The images can be viewed on the built-in viewfinder. It allows both 14 bit thermal and digital visual images to be converted to JPEG files so a second visual camera is not needed. The Bluetooth wireless feature allows up to 30 seconds of voice comment to be recorded with each image file. The S65 is approximately the same size and shape as a large battery camping flashlight.

ThermaCAM Researcher software allows the camera to interface with PC-based computer systems and to record directly via firewire at 65 frames per second. These capabilities make it ideal for use on live and moving animals. The purchase price of the S65 in 2006 was $49,000.

## Use in "Physiology of Washing Sea Otters"

When sea otters become oiled the primary means of removing oil is to wash them in warm dilute detergent with prolonged rinsing in warm water, forced air drying, and recovery with variable access to sea water (Williams and Davis, 1995). The process of anesthetizing, washing, rinsing and drying sea otters, each taken alone, and the animal's recovery and introduction to water are a series of complex interactions between an animal with a very high metabolic rate, little body fat, and an often cold environment. Using a deconstructionist science approach, the thermoregulatory effects of each of these steps are being investigated under controlled circumstances, so that the influence of each step on the success of the whole operation can be better understood. This research project, funded separately from the purchase of the ThermaCAM S65 by the SSEP program was designated contract number P0375032 "Investigating the Thermoregulatory Physiology of Washing Sea Otters." This report will not cover the details of that project but the following images were generated as part of contract number P0375032 using the ThermaCAM S65.

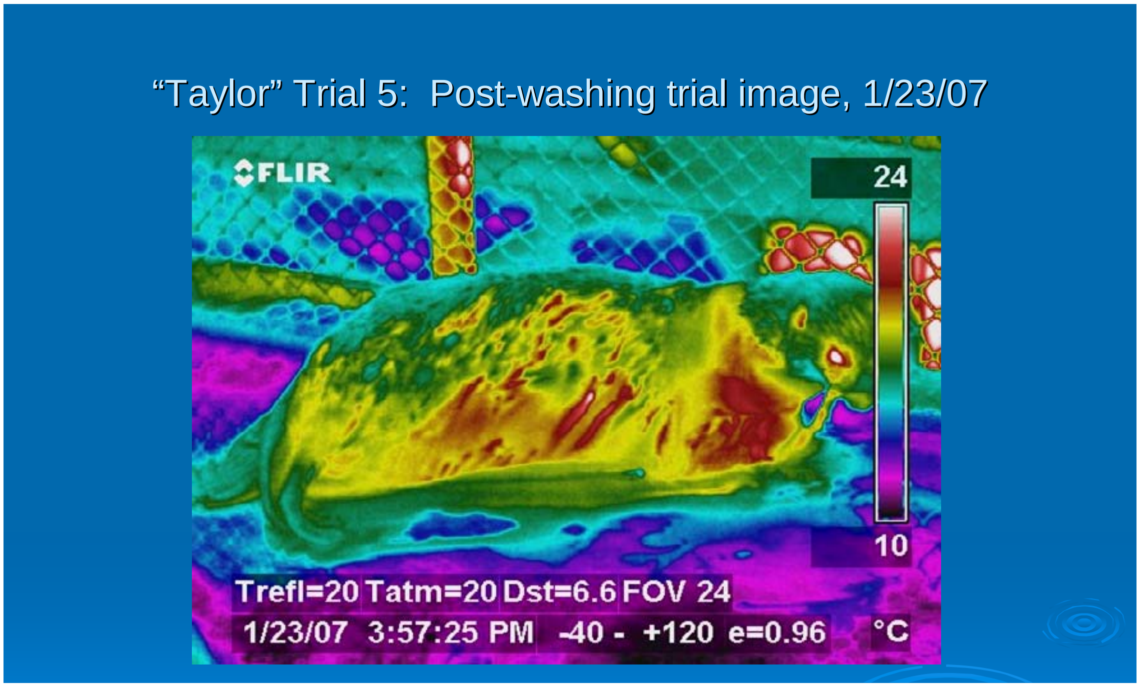



Figure 1. Sea Otter “Taylor” post-washing trial image taken with ThermaCAM S65 on 1/23/07, six hours post wash and return to warm fresh water. Core temperature returning toward normal, “watery” look and IR heat loss line up to neck (only head looks normal), subcutaneous temperatures in washed areas several degrees below normal.

Thermal images taken before washing or of the unwashed portions of a sea otter (cover photo) clearly show that normal fur is relatively cool (approximately 20C based on scale provided at right) and allow less radiation of heat into the environment. Thermal images taken after washing and during recovery (above and below, Figures 1 and 2) clearly show areas of heat loss and allow the observer to follow the size and shape of these areas over time as the animal grooms it’s coat. Warm water in the range of 20-23C can be seen streaming off the otter above 6 hours after it was washed from the shoulders down. This is the same amount of heat radiated from the entirely un-furred area around the eye. In the picture on the next page is the same animal 48 hours later, although the colors are similar, the scale has been adjusted so that red and yellow are 2-3C lower than in the image above. It can also be seen that heat is radiating out from beneath fluffed out fur, not streaming out with water draining from the coat, so less heat is being lost. It should also be noted that the hind feet are quite warm (greater than 21C). Sea otters shunt blood out of their hind limbs when they are cold, and this pattern is only seen in animals with core temperatures above normal. The S65 has software algorithms that will allow some calculation of quantity of heat lost from any one area. However, difficulty imaging all sides of an animal, and movement, make quantification of heat loss for the entire animal at any one point in time difficult.

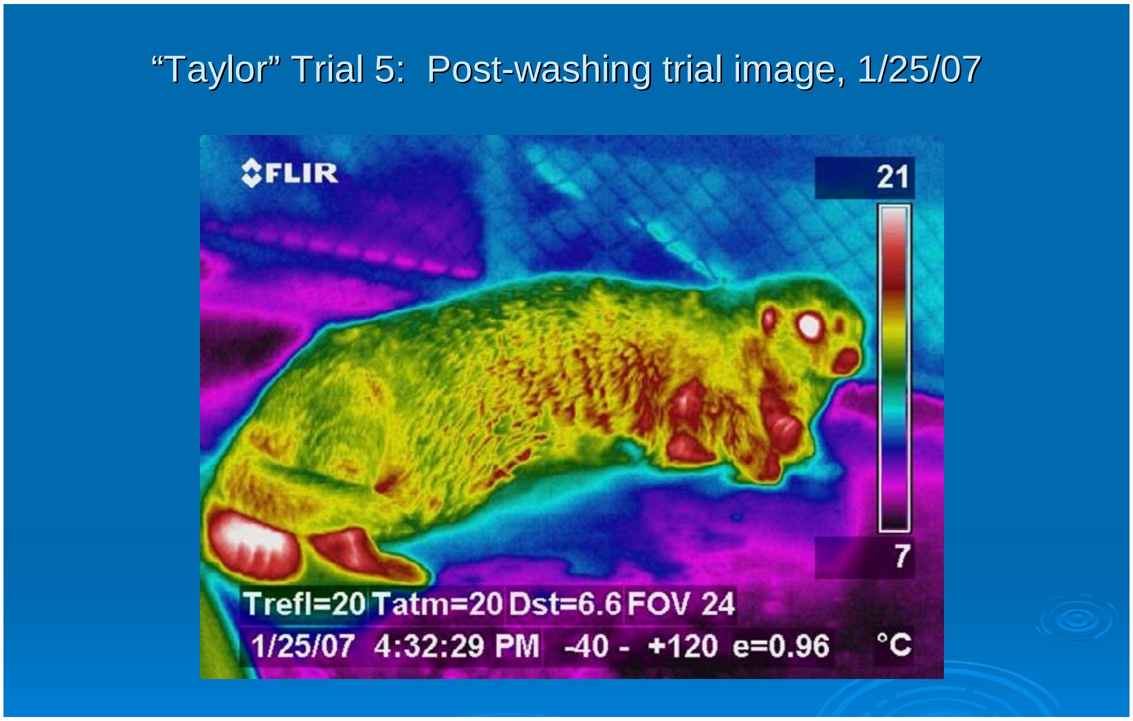



Figure 2. "Taylor" post-washing trial image taken with ThermaCAM S65, 1/25/07, 54 hours post wash, fur consistency and essentially all parameters at normal. Note: IR heat emission is not the only mark of "normal."

## Use in monitoring post-operative recovery and restoration of waterproofing in seabirds

Bird feathers lose their waterproofing when exposed to contaminants like petroleum, blood, and detergent. When feathers are compromised, energy is expended to maintain thermoregulation. The feather's rapid return to function allows birds to regain buoyancy and insulation as the waterproof feathers trap air against the bird's body. Tools that allow us to better evaluate and manage this return to function decrease recovery time and improve rehabilitation success.

Serial thermograms of Western grebes were recorded and used to monitor post-operative recovery following surgery to implant intracelomic radiotransmitters (Massey et al, 2008, Figures 3 and 4). A thermogram was taken every day for 9 days postoperatively and the researchers were able track diminishing heat loss from the surgery site. Thermograms appeared to be more sensitive at detecting heat loss than core body temperature taken at the cloaca and were considerably easier and less stressful to obtain. During the *M/V Cosco Busan* oiled wildlife response, control birds (surf scoters) from an Oiled Wildlife Care Network post-release survival study were compared pre- and post-wash to assess heat loss from various body areas. This was done as a preliminary project to evaluate the possibility of using thermography as a tool to remotely monitor birds' waterproofing while housed in pre-release conditioning pools. Thermograms were taken as time allowed during regular care procedures. Thermographic monitoring allowed birds to be handled less frequently (resulting in less stress) and had the potential to be a more sensitive indicator of poor waterproofing than behavioral observations.

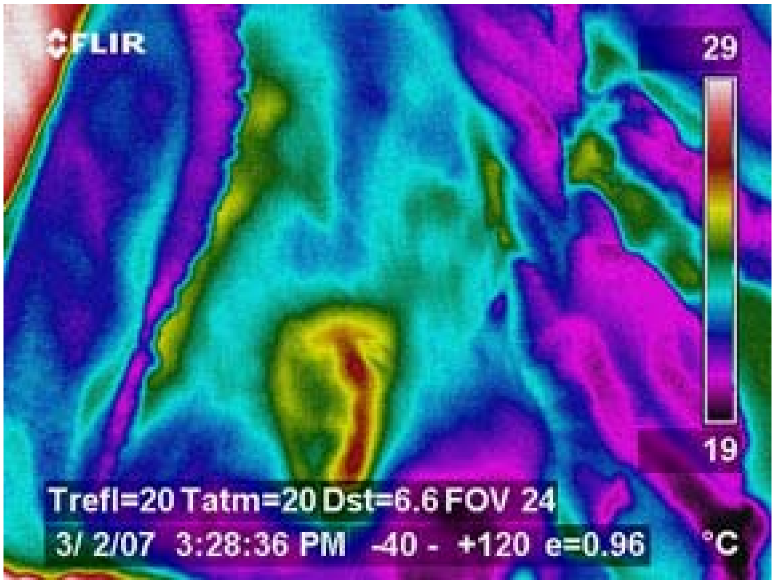



Figure 3. Thermogram demonstrating heat loss from abdominal surgery site

Figure 4. Reference color image of bird depicted in thermogram, note that the visual image does not show whether or not the bird is waterproof.

## Discussion

This study has shown that the FLIR ThermaCAM S65 is a very useful tool in determining where and when changes in sea otter fur coat thermal retention properties have been altered. Further, the S65 allows quantification of heat loss and comparison over time. Although less work of a similar nature has been accomplished with sea birds, it appears that this technology has great promise with these species as well.

Potential for use in the field as an oil slick detection tool was not attempted during the time frame reported here. The ThermaCAM S65 is a complicated and somewhat delicate device. It is unlikely that sending it out with an inexperienced person for field testing will result in much useful information being gained. To optimize its testing and use CDFG-OSPR should consider assigning a technician the responsibility of testing it for a variety of uses and under a variety of circumstances if its full potential is to be realized.

## Citations

Williams TM, Davis RW. 1995. Emergency care and rehabilitation of oiled sea otters. University of Alaska Press, LCN 94-47056.

Massey JG, Gaydos JK, Gaskins LA, Ziccardi MH. Thermography as a postoperative monitoring tool for seabirds. Proceedings of the Association of Avian Veterinarians. 2008:21.

ThermaCAM S65 Operating Manual