APPENDIX D

2010 KELP SURVEY METHODS OVERVIEW

Imagery Acquisition and Data Processing

The first digital multispectral imagery (DMSI) of kelp canopy off Oregon was acquired in 2010 with the intention of repeating the only other coastwide survey off Oregon (1990 film-based imagery). Other kelp surveys off Oregon from 1996 to 2000 were regional only; between Orford Reef and Rogue Reef. Ocean Imaging (OI) was contracted for the 2010 survey. Prior to data acquisition, ODFW conducted an aerial reconnaissance survey aboard a USCG helicopter. Our observations, along with those of local fishermen confirmed that kelp beds were notably sparse on the major reefs compared to previous years and nearly absent north of Cape Foulweather, other than a small kelp bed at Cape Lookout. As such, we deemed it unnecessary to conduct the survey coastwide, and opted to survey the region south of Cape Foulweather.

Poor weather and ocean conditions during the few suitable tide windows in September precluded acquiring the imagery until October 5 and 6. Survey flights were delayed until the fog cleared; tide height during data acquisition were between 1.12 - 5.35 ft. Intense fog and low cloud ceiling prevented the surveying north of Cape Arago. Additional survey information is provided in ODFW's 2010 Kelp Report.

Kelp imagery was collected using OI's DMSC MKII multispectral camera at a spatial resolution of 1 meter (*compared to 0.2286 m in 2022*). The DMSC's 4 available channels were configured to maximize surface and subsurface kelp detection using narrowband (10nm) interference filters with one channel being dedicated to deep near-IR (for surface kelp separation) and three channels at specific wavelengths within 450-680 nm.

Each DMSC frame collected was georeferenced using OI's direct georeferencing program based off position data logged by the DMSC imager and their Oxford Technologies DGPS/IMU unit. Each frame location was carefully compared to a USGS DOQQ or Microsoft Virtual Earth aerial imagery to confirm geo-location accuracy. Spatial adjustments were made as necessary. Spatial accuracy was within four meters (90% CE).

Mosaics were generated for each of the major kelp bed priority areas as well as the smaller, more isolated beds. Application of OI's proprietary algorithms facilitated classification of kelp canopy on the surface and submerged kelp (to 1 meter below surface) in the spectral signal. Details of the kelp classification methodology are provided in the 2010 Kelp Report, available upon request. The final thematic maps were provided in raster GIS format and ESRI shapefile format.

Kelp Classification Methodology

Submerged and Exposed Combined Classification: Following the creation of DMSC image mosaics for each of the kelp bed priority regions as well as a few small, isolated beds, thematic GIS layers were created showing submerged and exposed kelp as a single class and as two separate classes. The single-class combined product was created using ERDAS Imagine's ISODATA unsupervised classification function. The inputs to the classification routine included each of the four DMSC bands (band 1 centered at 451 nm, band 2 centered at 551 nm, band 3 centered at 675 nm and band 4 centered at 780 nm) as well as the band-ratio image product of log of band 4 and log of band 1 (ln band4 / ln band1) and a modified NDVI image product using bands 1 and 4 (band4 – band1 / band4 + band1). Using the 4-banded imagery along with the image products above, the resulting thematic map was then manually edited to reclassify misclassified pixels.

Classification Showing Submerged and Exposed Kelp as Separate Classes: In order to generate a classification product with submerged kelp and exposed kelp separated into two distinct classes, the DMSC band 4 (near-IR at 780 nm), band 1 (blue at 451 nm) and the band 4 over band 1 ratio product were closely analyzed. Reflectance signatures in the near-IR part of the electromagnetic spectrum are traditionally used to isolate live vegetation in multispectral imagery. Exposed (and some submerged) kelp therefore show a very strong reflectance signature in the DMSC band 4. However, light in the near-IR part of the spectrum will show the largest attenuation coefficient – meaning that light of this wavelength will be absorbed by water and scattered by particles faster in the water column than the red, green and blue wavelengths. The DMSC band 1 showing reflectance in the blue part of the spectrum has the lowest attenuation coefficient meaning that light (and resulting reflectance) will penetrate (and be reflected back) deeper in the water column. While knowing the exact attenuation coefficient and hence the depth penetration of light for these bands was impossible to determine for these coastal waters during data acquisition without precise field measurements, the depth penetration of band 4 (near-IR) was estimated to be roughly one meter. Visual comparison analysis of DMSC band 4, band 1, the band4/band1 ratio product and bands 4-2-1 displayed as "RGB" for each kelp bed mosaic resulted in determination of a digital number (DN) cut-off in the band4/band1 ratio image which could then be applied to the raster image. The single-kelp class product was first used to mask out any non-kelp pixels in each mosaic. The DN cut-off was then used to separate the single-kelp classification into two distinct classes, exposed and submerged.