Fishery Data Series No. 12-69

The Taku River Habitats Project: Implementation and Progress during Years I and II (2007, 2008)

by

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and

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November 2012

Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ADF&G Fishery Data Series was established in 1987 for the publication of Division of Sport Fish technically oriented results for a single project or group of closely related projects, and in 2004 became a joint divisional series with the Division of Commercial Fisheries. Fishery Data Series reports are intended for fishery and other technical professionals and are available through the Alaska State Library and on the Internet: http://www.adfg.alaska.gov/sf/publications/. This publication has undergone editorial and peer review.

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ABSTRACT

A multi-year juvenile salmonid habitat identification project was initiated in the Taku River watershed in Northern Southeast Alaska during 2007–2008. Activities during this phase of the project focused on remote-sensed image acquisition, georeferencing, terrain correction of satellite imagery, and spatial data collection associated with juvenile salmonid capture efforts. Remote-sensed imagery was acquired via a digital aerial photography system in September of 2007 and again in May of 2008. Quickbird Satellite Imagery was purchased in 2006, which included standard ortho-ready geotiff images of both panchromatic and multispectral bands. Subsequent georeferencing, terrain correction, and mosaic creation were conducted prior to geographical information system integration. Spatial data associated with juvenile salmonid capture efforts were collected to demarcate the extents of trapping areas associated with stock assessment activities, which overlapped with the Taku River Habitats project area.

Key words: Taku River, GIS, remote-sensed, ortho-mosaic, habitat, salmonid, panchromatic, multispectral, stock assessment

INTRODUCTION

Within Southeast Alaska (SE AK), the largest watersheds include those systems originating as headwaters in British Columbia, and as Healey (1991) and others have observed (McPherson et al. 2005; Jones III et al. 2006), these mainland river systems typically produce the largest runs of salmon. The significant production of salmonids in these watersheds contributes substantially to the complex food webs sustaining healthy ecosystems, as well as the economic and social linkages important to the surrounding communities. These mainland river systems provide an extensive network of spawning, rearing and migration habitat. Benefits related to the productivity of these large dynamic rivers provide a diverse resource enjoyed by multiple user groups and contribute significantly to the local and regional economy.

Despite the well-established doctrine that salmonid abundance, distribution, and production are strongly influenced by suitable habitat quantity and quality (Knudsen 2002), current fishery management scenarios rarely take these factors into consideration. This apparent oversight is generally not associated with a lack of recognition that habitat is important; rather, it is mired in the difficulty of understanding the complex relationships inherent in ecosystems and in managing the resources with only a rudimentary understanding of how individual components (i.e., fish, prey, habitats) interact (Knudsen 2002). Competing land uses for the same resources and insufficient data on current landscape conditions exacerbate the problem.

Here, then, is the impetus for identifying tools and methodologies to accurately map and monitor the critical freshwater habitats that promote the sustainability of salmonid populations. Only when management agencies have the means to identify and delineate fluvial habitats is it possible to begin exploring how these habitats affect salmonid distribution patterns, abundance and productivity. Recent advances in remote-sensing technologies and the applied use in fisheries research and management (Torgersen et al. 1999, 2001, 2004, 2006; Fausch et al. 2002; Whited et al. 2003; Gresswell et al. 2006) provide an opportunity to identify habitats at a scale and cost not practical through traditional “on-the-ground” field surveys. This is especially true in the largest and generally more remote mainland river systems of SE AK.

Habitat degradation continues to be one of the leading factors in the decline of salmon in the Pacific Northwest (Beechie et al. 1994; Thompson and Lee 2000; Rosenfeld 2003; Kaufman and Hughes 2006). Although much of Alaska still remains in a near-pristine state, it would be potentially damaging to ignore challenges facing fishery management agencies in the Pacific Northwest (and likely across the globe) where they look to offset the degradation or loss of fish habitat as fisheries decline. Further, providing an assessment of habitat associated with healthy salmonid stocks (as currently found in Alaska), rather than one associated with depleted, diminished, or “of concern” stocks is the most straightforward means to determine and evaluate the habitat parameters that lead or contribute to a healthy stock in the first place.

The Salmon Habitats of the Taku River (hereafter, Taku River Habitats) project is the next phase of a related project originally established in 2001 in an effort to develop alternative strategies and methodologies to monitor and assess international watersheds that sustain SE AK’s largest salmon-producing systems. Work occurring between 2001 and 2007 focused on the Unuk River (Figure 1), as part of the Transboundary Rivers–Sentinel Watershed Project. This work yielded several publications (Smikrud and Prakash 2006; Smikrud, 2007; Smikrud et al. 2008) and provided a foundation helpful in identifying fluvial habitats of large mainland river systems. Pacific Coast Salmon Recovery Fund support in 2007–2008 to the Mainland Rivers Watershed project (as the Taku River Habitats project was formerly titled) contributed funds necessary to begin identifying habitat and juvenile salmonid distribution patterns throughout the U.S. portion of the Taku River above saltwater influence. This document therefore details activities and results from work conducted during 2007 and 2008.

A concurrent and complimentary project supported through a separate funding source (State Wildlife Grant [SWG]) was initiated during 2007 and is anticipated to continue for the next five years. The Nearshore Marine and Estuarine Habitat Project: Taku River and Inlet (hereafter, Taku Nearshore SWG project) identified similar remote-sensed data products (i.e., habitat identification and classification), in conjunction with various fish sampling methodologies to begin exploring fish habitat associations in the estuary and tidally influenced portions of the Taku River. Cumulatively, the two projects will use a combination of remote-sensed/field verified habitat identification methods and fish sampling to identify fish-habitat associations within the entire U.S. portion of the Taku River and adjacent floodplain, as well as the marine waters of Taku Inlet.

This information will be immediately useful to the state, assisting in determination of what portions of the Taku River floodplain are most important to anadromous fish, including salmonids, and therefore may require consideration for additional protection. Both of these projects are consistent with strategies and priorities of the Alaska Department of Fish and Game, Division of Sport Fish (ADF&G–SF) Strategic Plan (ADF&G 2010).

OBJECTIVES

The overall goal of this project is to develop methodologies that can be used to assess, quantify and characterize juvenile salmonid habitat associations in the Taku River. Because the overall goal of the project could not be completed in one step or year, achievement focused on several clearly defined incremental objectives and additional work tasks. Beginning in 2007, objectives focused on acquiring the remote-sensed imagery for the entire Taku River project area (approximately 144 km^2), in addition to outreach and coordination with ADF&G–SF stock assessment crews. Image acquisition would address current objectives by providing fine-scale base layer imagery, as well as providing the foundation for producing a detailed landcover classification for future (2009–2011) objectives. Activities during 2008 included additional image acquisition (including for the adjacent Taku Nearshore SWG project area) and continued collaboration and spatial data capture with juvenile salmonid stock assessment crews of ADF&G–SF.

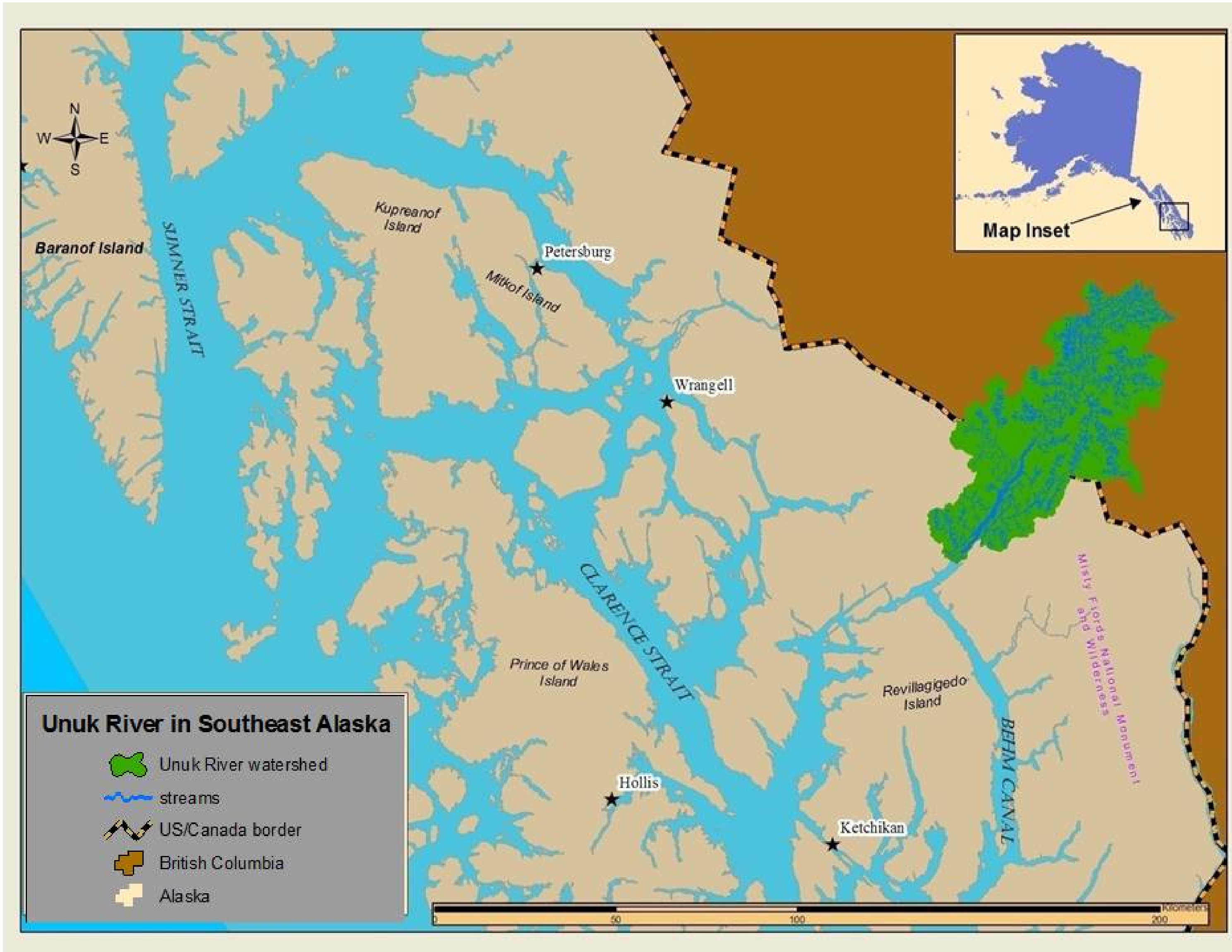

Figure 1.–Location of the Unuk River watershed and most significant tributaries in Southern Southeast Alaska.

Re-defined objectives to achieve the overall goal of this project and addressed during 2007–2008 included:

1. Image acquisition:

    i. Using digital aerial photography (DAP) system, acquire high-resolution digital imagery (visible: Red (0.63–0.69 µm), Green (0.52–0.60 µm), and Blue (0.45–0.52 µm)—hereafter, visible RGB—and thermal infrared: 7.5–13.0 µm) encompassing specified portions of the Taku River floodplain with a ground resolution pixel size of ≤30 cm for the visible RGB, and ≤2.5 m for thermal infrared.

    ii. Purchase Quickbird[1] (© 2007 DigitalGlobe, Inc.) high-resolution digital imagery (panchromatic and multi-spectral) encompassing specified portions of the Taku River project area with a ground resolution pixel size of 60 cm (panchromatic) and 2.4 m (multi-spectral).

2. Georectification and ortho-mosaic production (Quickbird panchromatic and multi-spectral digital imagery): georeference and orthorectify the standard Quickbird imagery products to base-layer imagery in North America Datum (NAD) 83, State Plane Federal Information Processing Standard (FIPS) 5001 projection. Mosaic individual ortho-images into seamless ortho-mosaics in above mentioned projection.

3. ADF&G–SF stock assessment data integration: integrate juvenile salmonid catch and effort information obtained from ADF&G–SF stock assessment activities during 2008 into the project geographic information system (GIS) for the Taku River project area, including:

    i. using global positioning system (GPS) data, identify and demarcate the extent of individual trap lines and trapping sites/areas within the Taku River, which are associated with juvenile salmonid (Chinook and coho salmon only) smolt trapping efforts; and

    ii. create GIS shapefiles (point, polygon) of all juvenile salmon catch and effort locations complete with full suite of associated attributes (e.g., x-y coordinates, species, life stage, activity, trap line, trapping site/area, etc.) for the 2008 stock assessment data.

Beginning in July 2009, project objectives will be focused on identifying juvenile salmonid distribution patterns within the Taku River floodplain and connected waterways and developing a landscape classification of the Taku River project area. Following completion of the current and 2010–2011 project objectives, a detailed thematic map of the Taku River floodplain, which delineates distinct habitat types, will be available. This establishes the foundation on which to begin exploring how salmonid distribution patterns are associated with these habitats.

STUDY AREA

The Taku River is a large, glacial transboundary river system originating in the Stikine Plateau of northwestern British Columbia, Canada (Figure 2). Following its origin, the mainstem Taku

[1] This and subsequent product names are provided for completeness and do not constitute product endorsement.

River flows through a dynamic floodplain surrounded by mountainous terrain before terminating nearly 300 km downstream at Taku Inlet in SE AK. The watershed has an extensive stream network, totaling nearly 17,000 km of stream length (Figure 3). The entire watershed drains an area greater than 17,000 km^2, with 75% of this area occurring within British Columbia, Canada.

The Taku River supports all five species of Pacific salmon, and may be the largest single producer of Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*) within SE AK. It also has significant numbers of sockeye and chum salmon relative to other stream systems in SE AK. The Taku River is only rivaled by the Stikine River in terms of importance to the local and regional economy. The economic and social benefits are not limited to one user group, but rather are important to commercial fisherman representing all gear types, recreational anglers, and likely ecotourism interests. Management of the Taku River salmonid fisheries generally has included various stock assessment techniques, including estimation of escapement, survival, harvest, and exploitation rates and patterns (Boyce et al. 2006).

The bounds of the Taku River Habitats project area within the Taku River watershed are constrained primarily to the floodplain below the US/Canada border and above the complimentary Taku Nearshore SWG project area, which approximates the extent of tidal influence. The Taku River Habitats project area was delineated laterally across the floodplain using the 60 m elevation contour, in order to further constrain activities to the currently “active” and “historic” floodplain. The delineation of the Taku River Habitats Project Area within the context provided by available imagery and hydrology is further illustrated in Figure 4.

METHODS

IMAGE ACQUISITION

ADF&G–SF Digital Aerial Photography (DAP) system

The DAP is an integrated photography system consisting of computers, external hard drives, camera sensors (visible RGB, thermal infrared), GPS, digital compass, inertial measurement unit, and associated software designed to be mobile and transported from the office to a De Havilland Beaver floatplane for image acquisition. All hardware components were controlled by individual software modules during image acquisition, which could be pre-determined or accessed in-flight.

Proprietary software from Terra-Mar, Inc. (Terra-Mar Resource Information Services, Inc. 2001), the developer of the DAP system, provides planning utilities that were used with a GIS to customize the following individual flight planning parameters:

1. Flight line placement and orientation;
2. Ground pixel resolution;
3. Image overlap considerations;
4. Flying altitude;
5. Image capture interval.

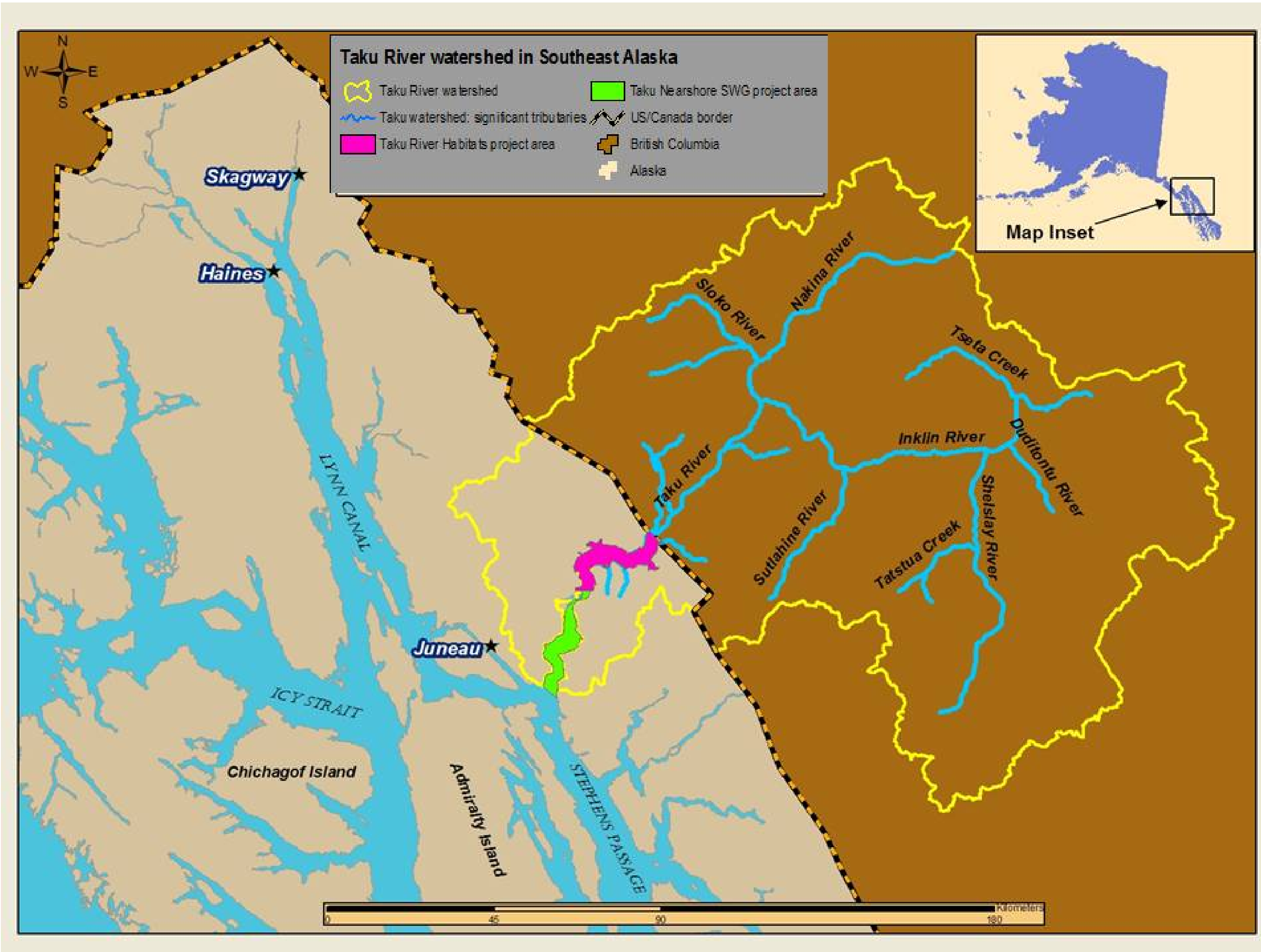

Figure 2.–Location of the Taku River watershed in Southeast Alaska, including 2 individual project areas, and significant tributaries.

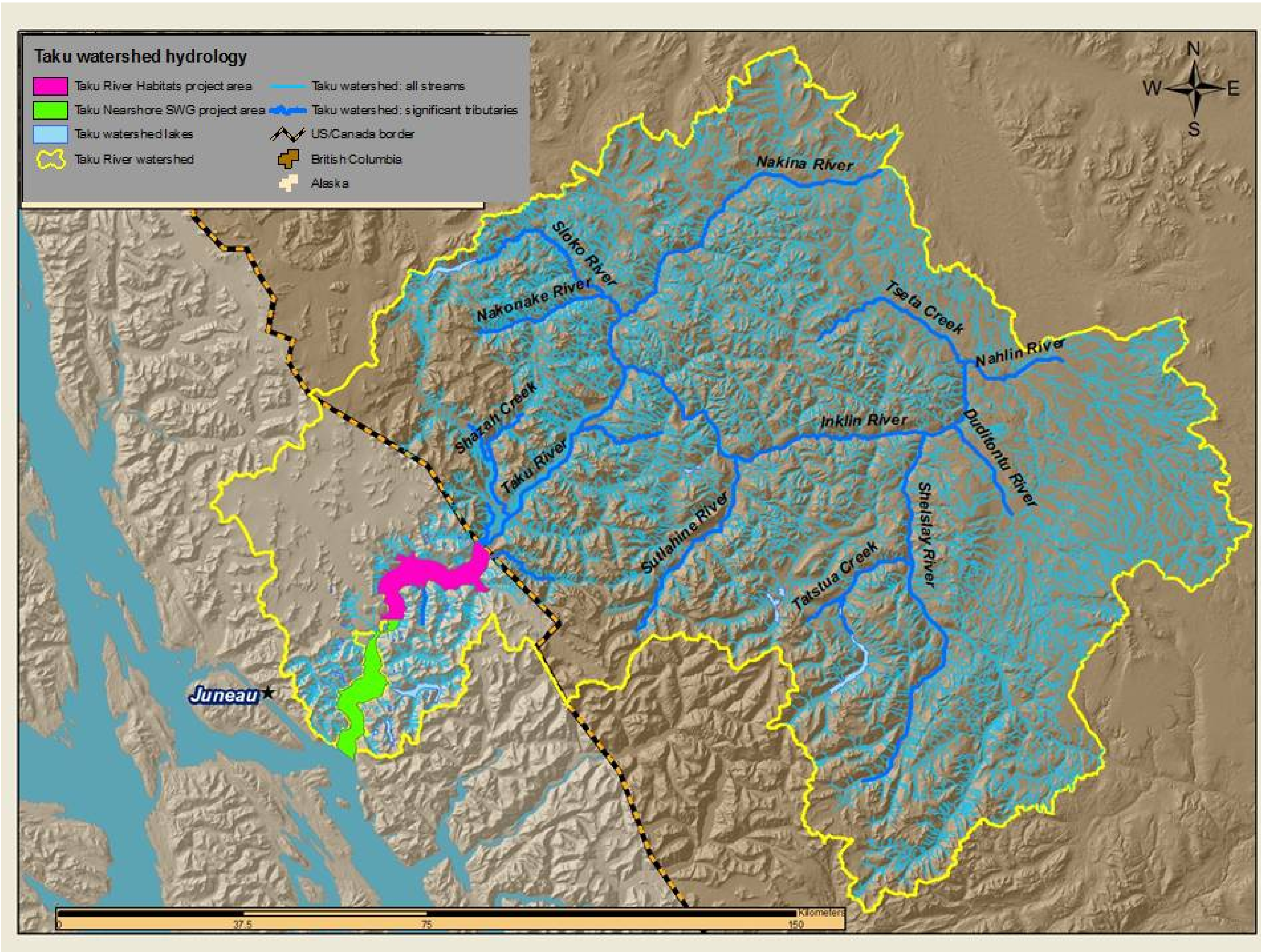

Figure 3.–Hydrology of the Taku River watershed in Southeast Alaska.

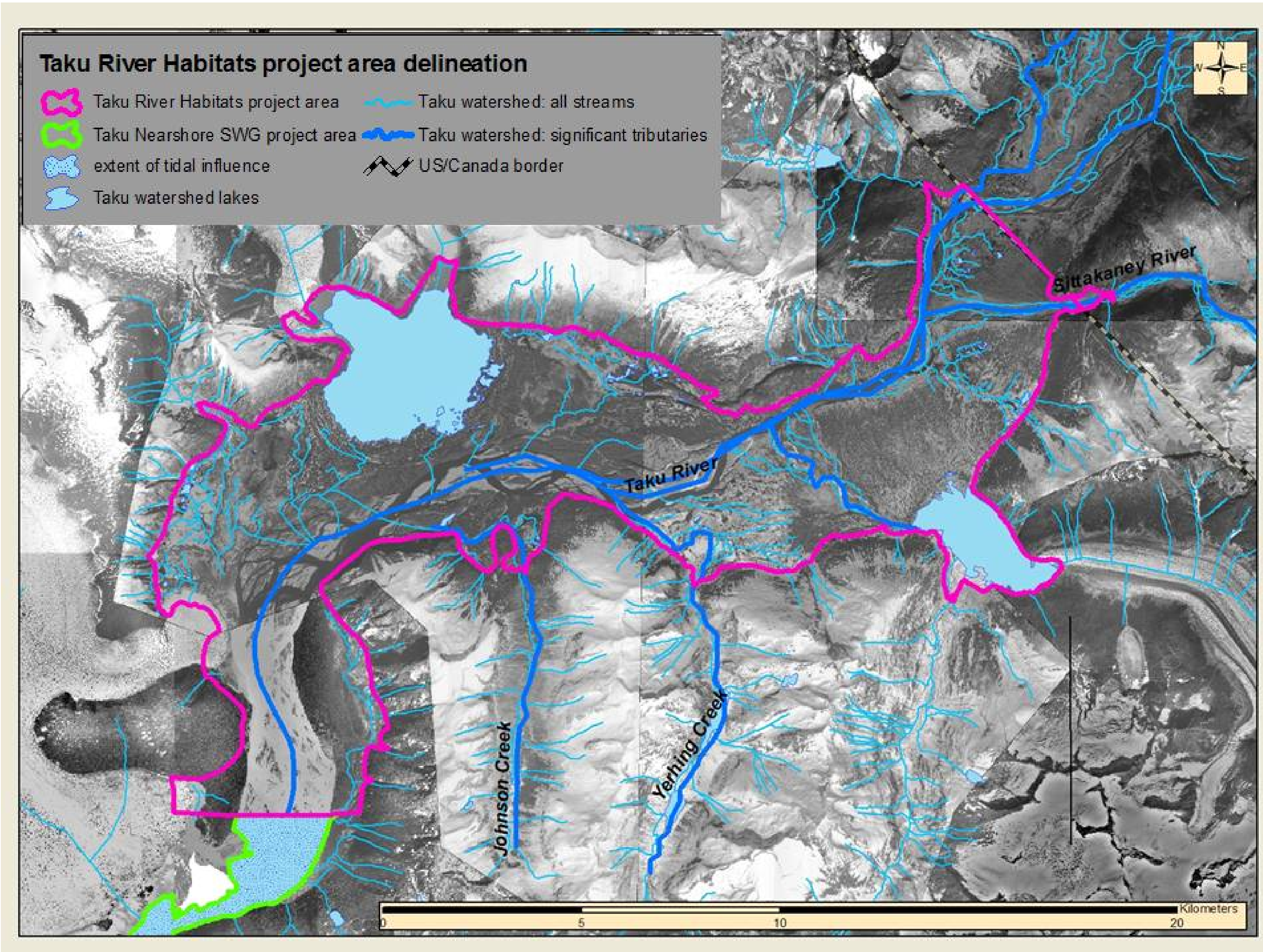

Figure 4.–Delineation of the Taku River Habitats project area within the Taku River watershed.

DAP: Flight Planning and Image Acquisition

ADF&G–SF staff used existing digital orthophoto quadrangle satellite imagery (© 2007 Digital Globe, Inc.–Quickbird) and Digital Elevation Models (DEMs) housed in a GIS to assist with pre-flight planning and flight line layout within the Taku River Habitats project area.

Evaluating previously captured imagery from the DAP system, it was determined that a ground resolution of 30 cm^2 (for the visible RGB sensor) was sufficient to identify features of interest across the floodplain of the Taku River. This lead to a corresponding thermal infrared resolution of approximately 2.4 m^2. In addition, both forward and side-lap values were set at approximately 60% for both sensor types, providing enough overlap to produce “stereo coverage” with adjacent images. In reality, the spacing of parallel flight lines controls the amount of side lap from image to image (across lines), and the photo interval controls the amount of forward lap (image to image within a line). Stereo coverage ensured a maximum amount of overlap on adjacent images, both along a line and between lines, to ensure reliable georectification without gaps.

Given these criteria, calculation of several critical parameters was possible for both sensors (e.g., visible RGB and thermal infrared). Flying height was constrained to 1,878 m with minor deviations caused by wind depressions and upheaval. The pilot attempted to maintain a relatively constant airspeed of 137 km/h to ensure a consistent photo interval of 20.58 seconds for both sensors as the shutter for both the visible RGB and thermal infrared were synched together. When multiple and parallel flight lines were necessary, they were spaced 540 m apart to provide sufficient side lap (across flight lines), as well as ensuring the entire floodplain extent was captured on the images. For areas where individual flight lines were used, the “center-line” of the image path was positioned to ensure equal image area on either side, essentially providing a complete view of the area of interest. The resultant image footprint of each sensor was 1,350 x 900 m^2 for the visible RGB and 1000 x 775 m^2 for the thermal infrared. The thermal infrared sensor was bore-sighted with the visible RGB to ensure that the smaller image footprint was centered within the extent of the visible RGB scene. Summary tables further describing flight planning parameters (e.g., flight line spacing, cost estimates, image resolution, image footprints) are provided in Appendices A, B, and C.

Accounting for the above parameters, flight lines were laid out in GIS to ensure that the entirety of the active floodplain within the project area would be captured. Ultimately, 34 individual flight lines were identified that would be flown to capture imagery over the project area; this included four distinct groupings of parallel flight lines, which individually were oriented in differing directions to accommodate the sinuosity of the Taku River floodplain. Because imagery for this project was captured in conjunction with the adjacent Taku Nearshore SWG project area, as well as extending flight lines across the US/Canada border, the actual length of individual flight lines was originally longer. All data captured during image acquisition were stored on dual hard drives associated with the dual computer setup, making it available for post-processing (see Georectification and Ortho-Mosaic Production).

Quickbird Satellite Imagery

Quickbird (© 2007 DigitalGlobe, Inc.) images were acquired for the Taku River study area through a cooperative project between the Taku River Tlingit First Nation and ADF&G-SF. Images were obtained within the U.S. and Canadian portions of the Taku River watershed as specified in the international project proposal. An official request was submitted to DigitalGlobe, Inc. (hereafter, DigitalGlobe), which included a polygon delineating the area of interest.

GEORECTIFICATION AND ORTHO-MOSAIC PRODUCTION

Standard ortho-ready images were provided by DigitalGlobe in a 16 bit, tiled geotiff format, referenced to a Universal Transverse Mercator (UTM), Zone 8N projection (NAD1983 datum). Tiled images were first assembled into mosaics by date acquired creating both a panchromatic (0.6 m^2) and a multispectral mosaic (2.44 m^2) for each image acquisition date. Standard ortho-ready products were delivered radiometrically calibrated and georeferenced by DigitalGlobe. The image mosaics were further geometrically corrected using commercial image processing software (ERDAS® Imagine). Ortho-mosaics were produced using a DEM and the rational polynomial coefficients (RPC) to correct for terrain distortion. The source for all DEMs used for ortho-processing was the Shuttle Radar Topography Mission for those areas within Alaska, and Terrain Resource Information Management for areas within British Columbia. A second-order polynomial correction was used in conjunction with the DEMs and the RPC. Lastly, the ortho-mosaics were visually inspected for geometric accuracy, including spatial alignment issues with other GIS data layers. Images were overlaid with the USFS ortho photos and adjacent ortho-mosaics. If additional geometric corrections were needed, the AutoSync module within ERDAS Imagine was used to finely adjust the images for better co-registration across all GIS layers.

ADF&G–SF STOCK ASSESSMENT DATA INTEGRATION

ADF&G–SF stock assessment activities occurred within and beyond the Taku River Habitats project area (Figure 5). ADF&G-SF, Region V staff worked cooperatively with Region I stock assessment crews to spatially locate the extent of areas associated with juvenile Chinook and coho salmon live-trapping efforts on the Taku River (Edgar Jones, Fishery Biologist III, ADF&G, Douglas, AK; operational plan available at ADF&G, Division of Sport Fish, Douglas). This work included an initial training period, with on the ground involvement by Region V and stock assessment crews, providing necessary guidance for spatial data capture concurrent with juvenile smolt capture.

All activities associated with this objective were guided by methods explained in a GPS data collection protocol (Appendix D). Region V staff was responsible for initial training and data recording along with stock assessment crews. After this time period, stock assessment crews were primarily responsible for all data collection efforts, while Region V staff provided data processing and analyses.

Data collection efforts during 2008 included documenting trapping effort and catch associated with trap lines and individual trapping areas, as well as spatially locating the extent of trap lines and individual trapping areas within the project area. Estimates of effort associated with coded wire tag (CWT) activities during 2008 included three parameters: 1) the number of days an individual trapping area was actively trapped with at least one minnow trap (DAYS); 2) the total number of minnow traps actively fished during an overnight soak at an individual trapping area (TRAPS); and 3) the product of these parameters, which equates to the variable TRAP DAYS, and expressed by the following formula for an individual trapping area j:

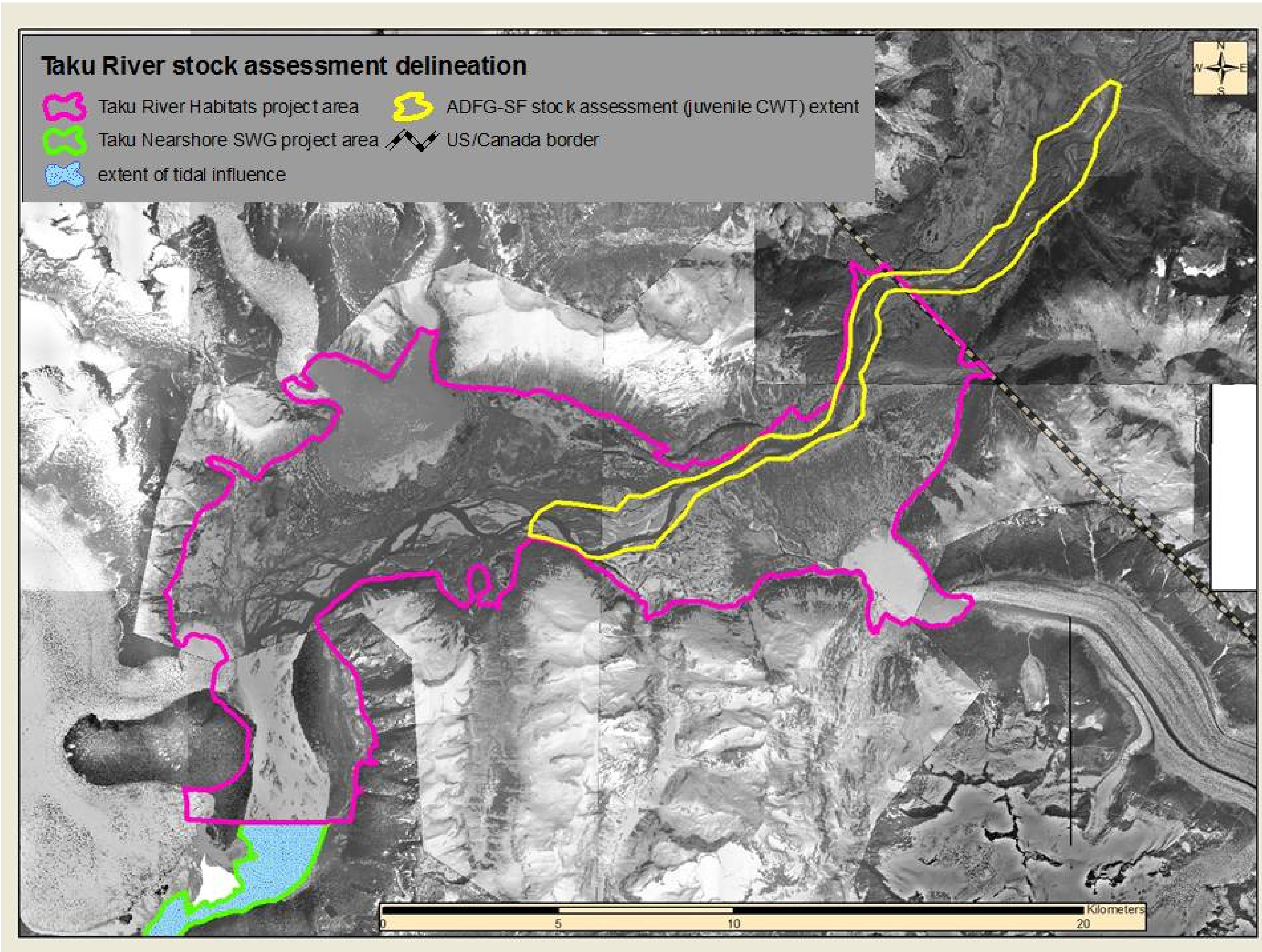

Figure 5.–Location and extent of ADF&G-SF stock assessment activity (juvenile salmonid coded wire tagging) on the Taku River.

$TRAP\ DAYS_i = DAYS_i \times TRAPS_i$;

Although a total of 132 individual trapping areas were visited by CWT crews, only 80 of these locations were spatially located. Estimates of catch associated with CWT activities represent the minimum number of Chinook and coho salmon (combined) captured, as these species were not always differentiated in the field. Total catch was the sum of catches in each area *j*:

$TOTAL\ CATCH = \sum CATCH_i$

RESULTS

IMAGE ACQUISITION

ADF&G-SF Digital Aerial Photography (DAP) system

All data results related to image acquisition and the DAP system is reported in the subsequent section.

DAP: Flight Planning and Image Acquisition

Imagery was acquired using the DAP system over the entire project area during non-consecutive days in 2007 and 2008, although > 90% of the images were captured during the third week of May 2008. Of the 34 flight lines flown within the project area, 24 were flown during a six-day span between May 23 and May 28, 2008. This represents over 92% of the total flight line length (266.4 km) within the project area. The 10 flight lines flown during 2007 (September 28 and October 4) were abbreviated in length (20.7 km) and represent less than 8% of the total. Flight line placement and acquisition dates are illustrated in Figure 6. A total of 758 images were captured along the 34 flight lines during all image acquisition flights (Figure 7).

Because the dual sensors on our DAP were synched, the same number of images were captured for both the RGB and thermal infrared. Similar to the flight line length, over 92% (n = 698) of all images were captured during the six-day stretch in 2008.

Quickbird Satellite Imagery

Due to the often cloudy and rainy weather inherent to SE AK, the Quickbird satellite was not able to acquire imagery for the entire study area during the same time period; therefore, the resulting image products spanned five separate dates: August 26, 2003, May 15, 2006, May 18, 2007, June 10, 2006, and July 3, 2006 (Figure 8).

GEORECTIFICATION AND ORTHO-MOSAIC PRODUCTION

A total of 252 image tiles were processed into 10 mosaics, one for each of the panchromatic and multispectral bands for each acquisition date.

Ground control points to use in the orthorectification process were not obtained, and therefore the residual positional error that remained in the orthorectified Quickbird imagery is associated with the error in using a coarse 30 m DEM to correct high spatial resolution images (i.e., 0.60 m panchromatic and 2.44 m multispectral). Overall, the ortho-mosaics were geometrically accurate in their position following terrain correction. Several images produced mis-registration between adjacent ortho-mosaics and USFS orthophotos with an error on the order of 20–70 m throughout the mosaic. To further refine co-registration, the AutoSync module within ERDAS Imagine worked effectively to tighten the relationship between images and associated GIS data layers.

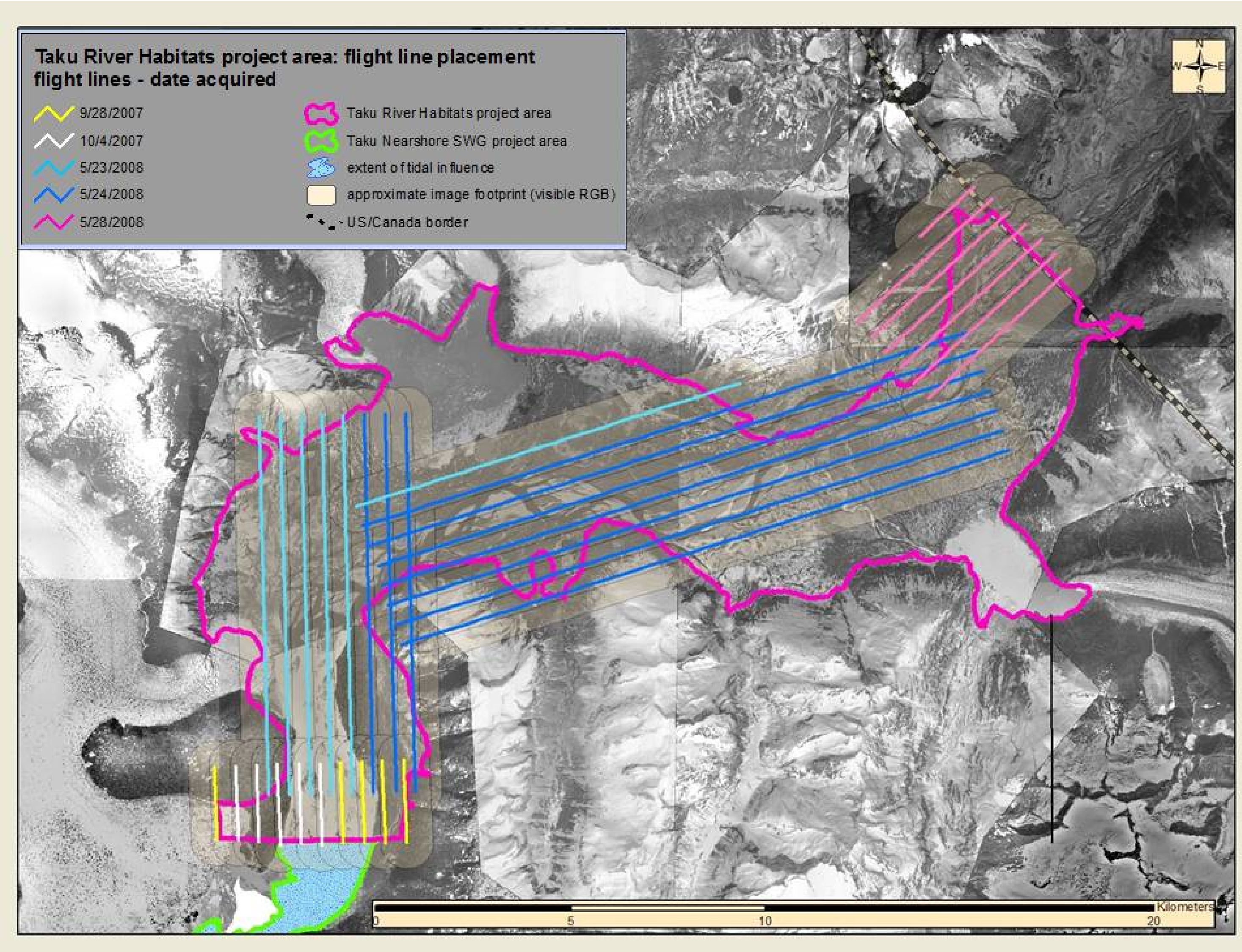

Figure 6.–Flight line placement and acquisition dates associated with image acquisition within the Taku River Habitats project area.

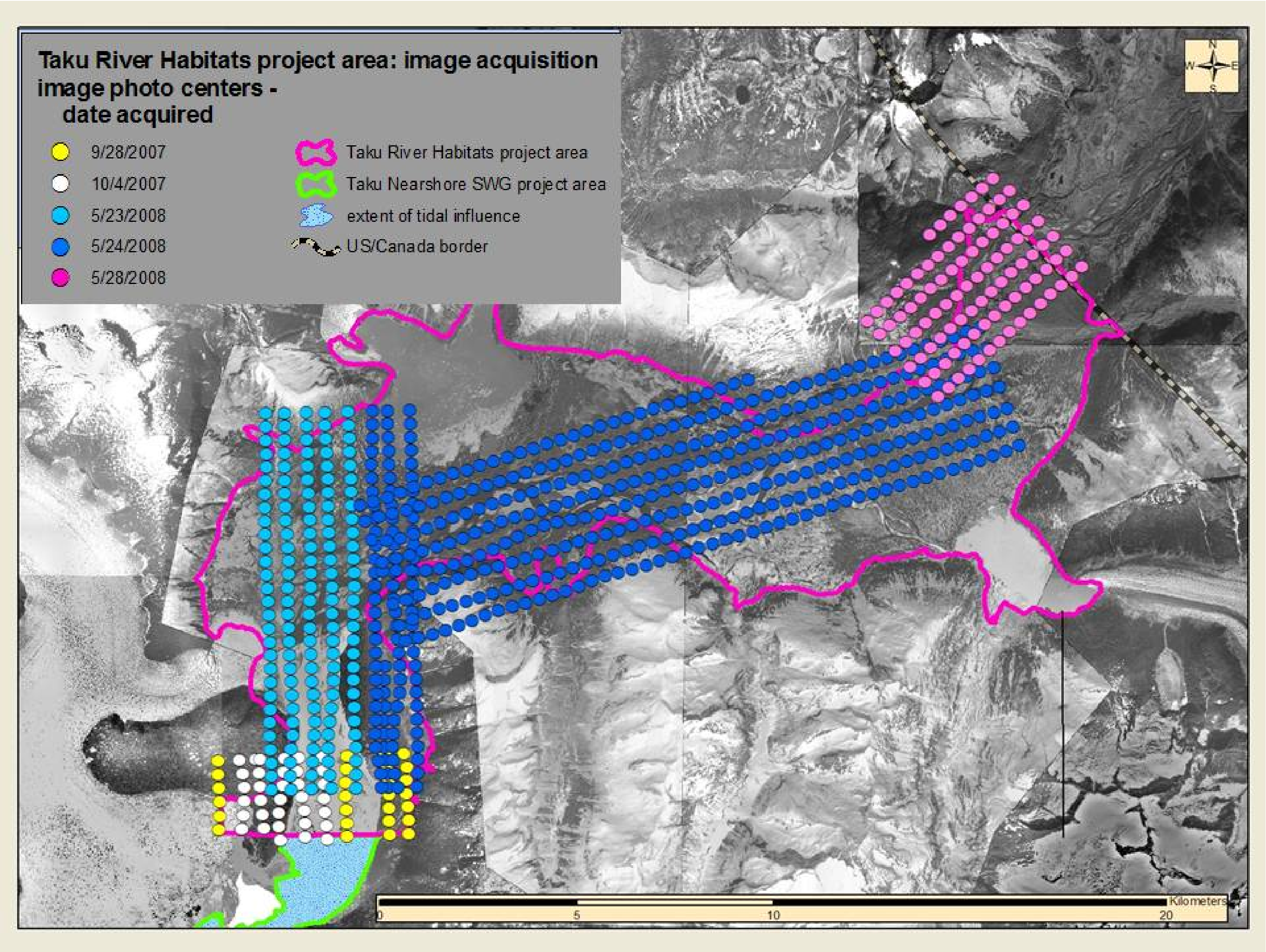

Figure 7.–Visible red, green, blue (visible RGB) and thermal infrared (IR) image acquisition dates associated with the Taku River Habitats project area.

ADF&G–SF STOCK ASSESSMENT DATA INTEGRATION

During 2008, CWT activities were carried out on the Taku River between April 11 and June 6. During this time, ADF&G-SF crews captured 328 GPS waypoints to identify the location of trap lines (n = 3) and individual trapping areas (n = 80, Figures 9 and 10). Due to missing GPS data, 52 individual trapping areas could not be mapped, although estimates of catch and effort were available for all 132 (80 + 52) locations.

Catch and effort (minimum or lower threshold) were estimated for each individual trapping area, except in four instances where these data were not collected. Effort was not applied consistently across trapping areas due to the varying size of the areas, as well as the differential number of traps and number of days each trap was fished. The number of days trapped at individual trapping areas ($DAYS_i$) varied from a low of a single day (at 20 different trapping areas) to a high of 55 days (at three different trapping areas). Total effort ($TRAP\ DAYS_i$) ranged between 1 and 433 for individual trapping areas. Across all trapping areas, the minimum total effort was 10,498 TRAP DAYS.

Catch data for trapping areas were not identified to species during CWT activities consistently, as mentioned in the Methods section. Therefore, only minimum estimates of catch for Chinook and coho salmon combined are available. During 2008, CWT crews captured a minimum of 2,750 coho salmon and 18,761 Chinook salmon. TOTAL CATCH during the same time period yielded 51,255 fish across all trapping areas. $CATCH_i$ within individual trapping areas ranged from a low of 0 to a high of 2,333 (Table 1).

Table 1.–Estimates of effort and catch by trap line associated with CWT activities during 2008 on the Taku River.

Trap line	Total effort (TRAP DAYS)	Total catch
Lower	3,658	20,493
Middle	2,781	12,851
Upper	4,059	17,911
Total	10,498	51,255

DISCUSSION

IMAGE ACQUISITION

The complete image set consisted of 758 individual images with similar "footprints" (i.e., amount of ground covered or depicted by a photograph) and spatial/spectral resolution that were captured during several image acquisition flights spanning eight months (September 28, 2007–May 28, 2008). Imagery that is used to identify habitats must have sufficient resolution (both spatial and spectral) to identify features/habitats at a consistent scale or minimum mapping unit.

Ideally, image acquisition across the entire Taku River Habitats project area (Figures 6–7) would have occurred on the same day, thereby providing imagery with consistent "views" of the landscape with respect to river levels (e.g., discharge, wetted width, gauge height, etc) and other environmental conditions (e.g., vegetation emergence or leaf-out). However, four logistical factors made this impossible: 1) the size of the project area was too large to fly on a single day,

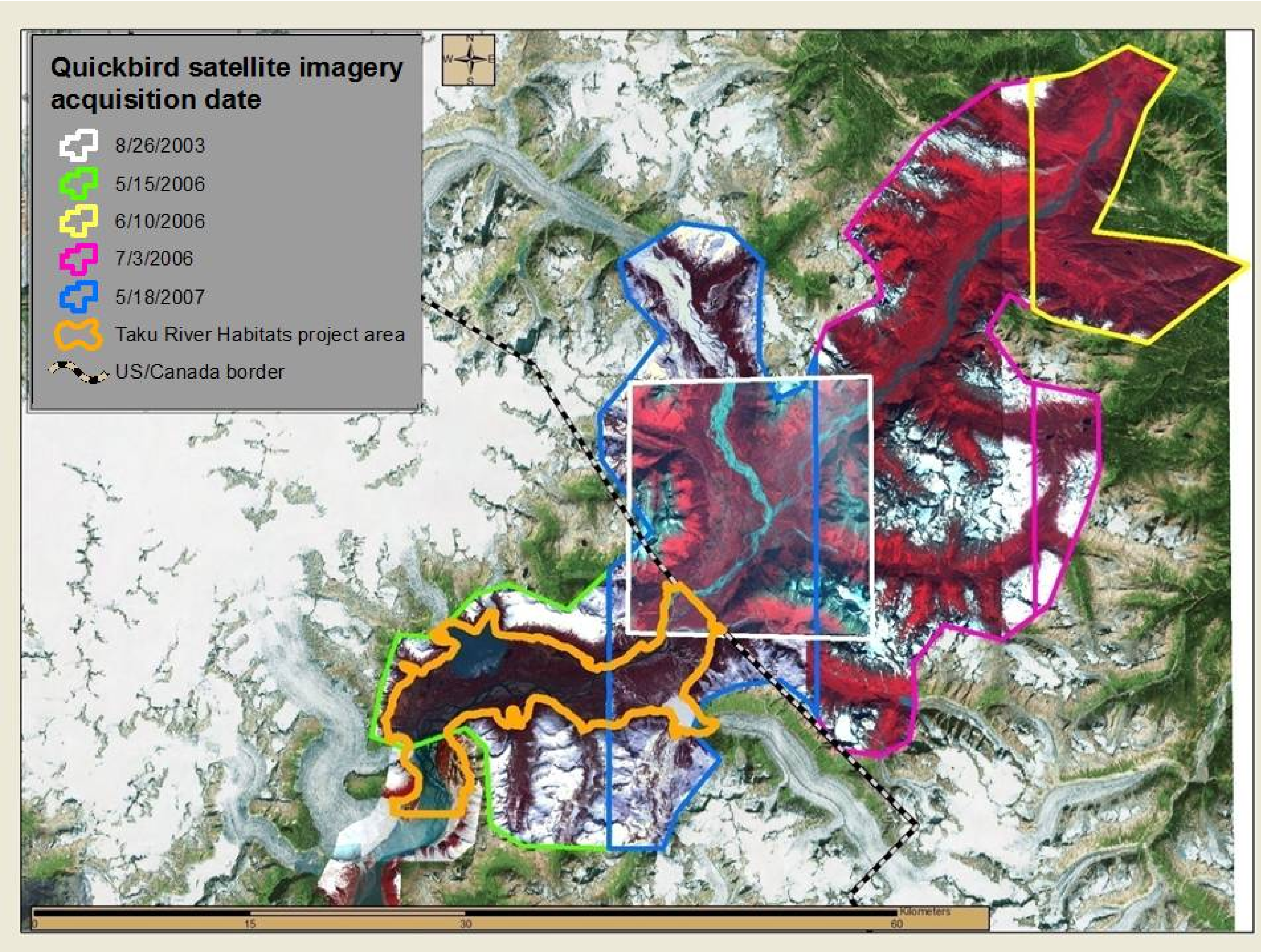

Figure 8.–Quickbird satellite imagery acquired for the Taku River Habitats project area.

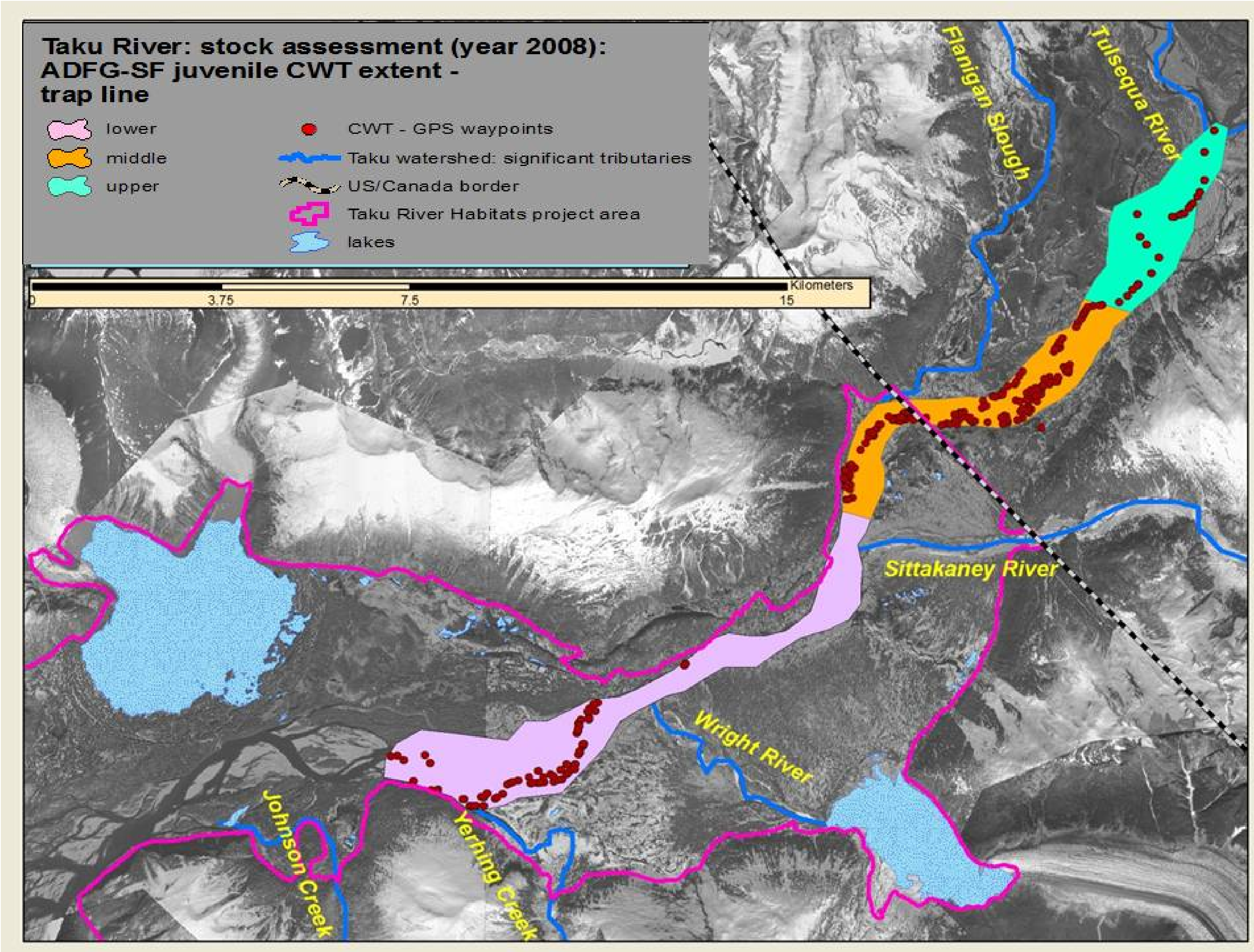

Figure 9.–Location of global positioning system (GPS) waypoints and individual trap lines (n=3) associated with coded wire tag (CWT) activities on the Taku River during 2008.

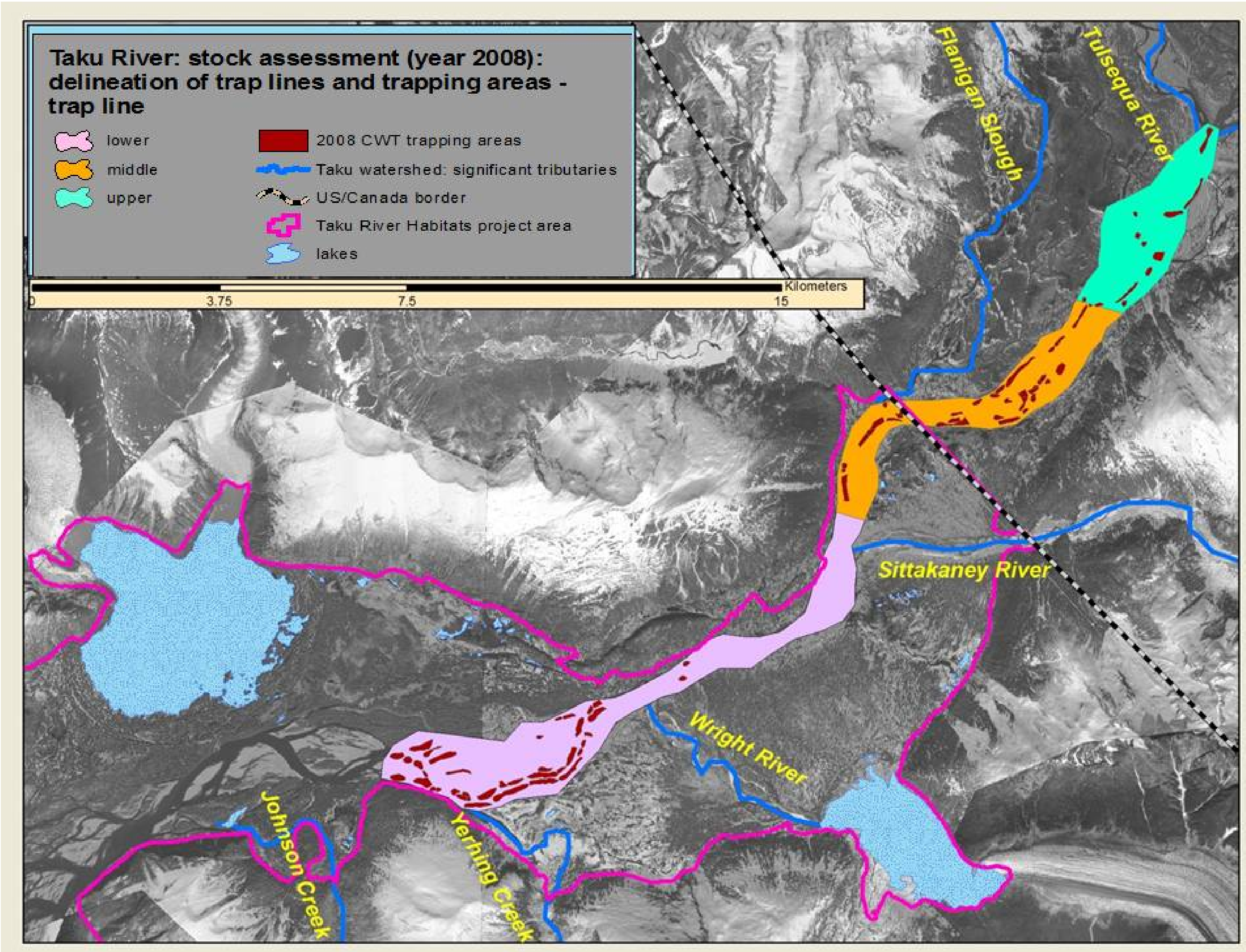

Figure 10.–Location of trap lines (n=3) and individual trapping areas (n=80) associated with coded wire tag (CWT) activities on the Taku River during 2008.

given the need to refuel after approximately 4½ hours; 2) local weather patterns were unfavorable during some scheduled missions and ultimately these patterns dictated when image acquisition missions could proceed, as days with light winds and high overcast were preferred; 3) chartering airplanes (De Havilland Beaver) several weeks in advance of known weather patterns often resulted in missed opportunities, or flights that had to be cancelled; and 4) a desired ground pixel size of 30 cm (visible RGB) for the imagery imposed a flying altitude of approximately 1,878 m with the DAP system; this equated to an individual image footprint of 1.215 km^2, or less than 0.1% of the entire project area and therefore required more narrowly spaced flight lines leading to additional flight time. Given all of these factors, it was impossible to acquire imagery over a very brief time span. However, as previously noted, approximately 92% of all images were captured over a six-day time period in May 2008.

Commercial satellite imagery has several benefits over the DAP, which would have resulted in all imagery being captured over a shorter period of time. Quickbird (Digital Globe®) satellite platforms orbit the earth at approximately 680 km, capturing images with ground footprints of 16.5 km^2, or nearly 16 times larger than those images captured with the DAP system. This allows rapid acquisition of imagery over a much larger area, thereby reducing concerns of time duration. However, weather patterns often delay image acquisition from these satellite platforms whereas the DAP includes rapid mobilization and acquisition of imagery as weather patterns permit.

GEORECTIFICATION AND ORTHO-MOSAIC PRODUCTION

The Quickbird satellite imagery provided high quality base-line imagery for the entire extent of the Taku River study area. The ortho-mosaics produced are geometrically accurate and GIS ready. Unfortunately, one limitation of this data set is that the images were acquired over a range of dates, resulting in varying landscape conditions across image scenes. Varying landscape conditions were primarily related to annual differences in river levels, as imagery for the majority of the Taku River project area was captured in mid-May of 2006 and 2007. While slight differences in vegetative emergence (e.g., deciduous and herbaceous) and water levels were present between the two years, the two-year mosaic of individual images was an improvement upon existing base-line imagery. Ultimately, Quickbird satellite imagery provided benefits that outweighed limitations, including a means to efficiently capture imagery for a large geographic area in short windows of time (relative to an individual mosaic) and providing high spatial resolution imagery, including a near-infrared band that is not available in USFS orthophotos or imagery acquired with the ADF&G–SF DAP system.

Although the Quickbird satellite imagery provided improved base-line imagery and allowed completion of the current objectives of this phase of the project (2007–2008), future objectives and considerations may require additional image processing or field data collection. Cumulatively, the differing ground conditions reflected in separate image sets present challenges to subsequent image classification and ultimately production of a consistent landscape classification across the entire Taku River project area. These issues will be addressed in future (2009–2011) objectives as the project continues.

ADF&G–SF STOCK ASSESSMENT DATA INTEGRATION

CWT efforts on the Taku River and other waterbodies in SE AK include the capture, tagging, and release of thousands of juvenile salmonids each year. Little effort is made to document the exact location of capture because it is not crucial to addressing the goals and objectives of most stock assessment projects. However, given the extremely large number of juvenile salmonids captured during these efforts, much can be gained if spatial data capture accompanied these activities. Although there was no sampling design for documenting capture location imposed on CWT juvenile salmonid capture efforts, the information does identify simple juvenile salmonid presence across the study area. These collaborative efforts will continue through the spring-summer of 2009. Beginning in July 2009, the ADF&G-SF will carry out a stratified fish sampling design to document juvenile salmonid distribution patterns with respect to unique watered habitat types across the Taku River project area. Watered habitat types will be identified and delineated across the project area using satellite imagery (e.g., Quickbird–DigitalGlobe, Inc.) and image classification techniques. This approach will provide a more robust data set from which to understand and evaluate juvenile salmonid distribution patterns and habitat preferences across the U.S. portion of the Taku River.

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APPENDIX A: DIGITAL AERIAL PHOTOGRAPHY FLIGHT PLANNING PARAMETER ESTIMATES FOR PERCENT SIDELAP AND FLIGHT LINE SPACING.

Appendix A.–Digital Aerial Photography system flight planning parameters (% side lap and flight line spacing) associated with varying ground image resolutions.

	Side lap (%) and flight line spacing (m)												
Ground pixel resolution (cm)	0%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	Ground pixel resolution (cm)	Flying altitude (m)
5	225	203	191	180	169	158	146	135	124	113	101	90	5	313
10	450	405	383	360	338	315	293	270	248	225	203	180	10	626
15	675	608	574	540	506	473	439	405	371	338	304	270	15	939
20	900	810	765	720	675	630	585	540	495	450	405	360	20	1,252
25	1,125	1,013	956	900	844	788	731	675	619	563	506	450	25	1,565
30	1,350	1,215	1,148	1,080	1,013	945	878	810	743	675	608	540	30	1,878
35	1,575	1,418	1,339	1,260	1,181	1,103	1,024	945	866	788	709	630	35	2,188
40	1,800	1,620	1,530	1,440	1,350	1,260	1,170	1,080	990	900	810	720	40	2,504
45	2,025	1,823	1,721	1,620	1519	1,418	1316	1,215	1,114	1,013	911	810	45	2,812
50	2,250	2,025	1,913	1,800	1,688	1,575	1,463	1,350	1,238	1,125	1,013	900	50	3,130
55	2,475	2,228	2,104	1,980	1,856	1,733	1,609	1,485	1361	1,238	1,114	990	55	3,438
60	2,700	2,430	2,295	2,160	2,025	1,890	1755	1,620	1,485	1,350	1,215	1,080	60	3,750
65	2,925	2,633	2,486	2,340	2,194	2,048	1,901	1,755	1,609	1,463	1,316	1,170	65	4,062
70	3,150	2,835	2,678	2,520	2,363	2,205	2,048	1,890	1,733	1,575	1418	1,260	70	4,375
75	3,375	3,038	2,869	2,700	2,531	2,363	2,194	2,025	1,856	1,688	1,519	1,350	75	4,688
80	3,600	3,240	3,060	2,880	2,700	2,520	2,340	2,160	1,980	1,800	1,620	1,440	80	5,000
85	3,825	3,443	3,251	3,060	2,869	2,678	2,486	2,295	2,104	1,913	1,721	1,530	85	5,312
90	4,050	3,645	3,443	3,240	3,038	2,835	2,633	2,430	2,228	2,025	1,823	1,620	90	5,625
95	4,275	3,848	3,634	3,420	3,206	2,993	2,779	2,565	2,351	2138	1,924	1,710	95	5,937
100	4,500	4,050	3,825	3,600	3,375	3,150	2,925	2,700	2,475	2,250	2,025	1,800	100	6,250

APPENDIX B: DIGITAL AERIAL PHOTOGRAPHY FLIGHT PLANNING PARAMETER ESTIMATES FOR IMAGE FOOTPRINT AREA.

Appendix B.–Digital aerial photography system flight planning parameters (photo scale and image footprint size) associated with varying flying altitudes and ground pixel resolutions.

Ground pixel resolution (cm)	Flying altitude (m)	Photo scale	Image footprint width (m):@ 4,500 pixels	Image footprint length (m):@ 3,000 pixels
5	313	1:6,250	225	150
10	2,051	1:12,500	450	300
15	939	1:18,750	675	450
20	1,252	1:25,000	900	600
25	1,565	1:31,250	1,125	750
30	1,878	1:37,500	1,350	900
35	2,188	1:43,750	1,575	1,050
40	2,504	1:50,000	1,800	1,200
45	2,812	1:56,250	2,025	1,350
50	3,130	1:62,250	2,250	1,500
55	3,438	1:68,750	2,475	1,650
60	3,750	1:75,000	2,700	1,800
65	4,062	1:81,250	2,925	1,950
70	4,375	1:87,500	3,150	2,100
75	4,688	1:93,750	3,375	2,250
80	5,000	1:100,000	3,600	2,400
85	5,312	1:106,250	3,825	2,550
90	5,612	1:112,500	4,050	2,700
95	5,937	1:118,750	4,275	2,850
100	6,250	1:125,000	4,500	3,000

APPENDIX C: DIGITAL AERIAL PHOTOGRAPHY FLIGHT PLANNING PARAMETER ESTIMATES FOR TIME AND COST.

Appendix C.–Estimates of time and cost associated with varying project area size and number of flight lines.

Km^2	Number of flight lines	Total miles of flight lines	Round-trip travel time[a]	Total flight time (hrs)	Estimated cost[b]
23.3	11	100	1 hour	2 hours 15 minutes	$1,350
64.7	18	234	1 hour	3 hours 45 minutes	$2,250
129.5	26	445	2 hours[c]	7 hours 15 minutes	$4,350
260.0	37	855	2 hours[c]	12 hours 20 minutes	$7,400
647.5	61	2020	5 hours[c]	28 hours 45 minutes	$17,250
1165.5	83	3570	8 hours[c]	50 hours	$30,000

[a] Round-trip travel assumes a 30 minute flight in each direction to reach project area and return to base of operations (airport, float pond, etc.).

[b] Estimated costs assume a $600 hourly rate for a De Havilland Beaver, given an associated total flight time.

[c] Round-trip travel that exceeds 6 hours (maximum flight time for a De Havilland Beaver), requires the rest of flight time to occur on a second day, and thus doubles for each 6+ hours required to complete the mission.

APPENDIX D: ADF&G-SF GPS DATA COLLECTION PROTOCOL: PROPER METHODS FOR SPATIAL DATA COLLECTION ASSOCIATED WITH VARIOUS FISH SURVEYS EMPLOYED BY STOCK RESEARCH.

Importance of Spatial Data to Fisheries Management and Research

Like many resource management agencies across the country, the Alaska Department of Fish and Game's mission is to protect, maintain and improve the fish, game and aquatic plant resources of the state. And almost everything that is done in our day-to-day activities, or conveyed to the public, is explicit to somewhere on the landscape. For example, research project plans typically describe specific locations where data need to be collected; news releases typically describe where users may or may NOT harvest resources, etc. Yet there is no standardized way to document where exactly these places are across the landscape and worse yet, no data management system to accommodate that type of information. Our intent is to layout some guidelines that can be used by others to assist in their spatial data collection efforts.

Fish Observation data captured with a spatial component (i.e., with a GPS waypoint identifying latitude/longitude) is a very useful tool, and can help facilitate a number of information needs for enhancing our ability to carry out the mission of the Department. Examples include: increasing our knowledge of fish distribution for purposes of protection and conservation; documenting where boundary markers are established for fishery openings; documenting where fish are trapped/observed during sampling events for return trips; use of site-specific fish locations to develop landscape-based models that estimate fish production; identifying areas on the landscape that are most important to users for purposes of conservation and protection.

Overview of the Global Positioning System (GPS)

The Global Positioning System (GPS) is a world-wide radio-navigation system formed from a constellation of 24 satellites with precise atomic clocks orbiting 11,000 km above the earth's surface, and their associated ground stations. Positions on earth are determined by receiving the radio signals being emitted, and measuring the very precise distances and time to the available satellite(s); the process uses mathematical "triangulation" calculations to compute the result.

Essentially, four visible satellites are necessary to accurately determine position, but three available satellites can do the same—albeit sometimes less reliably, depending on their constellation/configuration at that specific point in time. The steep terrain associated with certain parts of Alaska will at times present problems with obstructed views of the sky and therefore will play a role in how well the radio signals from the satellites are being received. However, use of external antennas, leaving units turned on over the course of the day while surveying, and waiting until certain times of day to collect data can all enhance one's ability to collect reasonably precise positions.

GPS Instrument Setup

There are a myriad of makes and models of consumer-grade GPS units available for purchase, but in the end, they all process and produce positional data the same. Before GPS units can be used for navigation or waypoint storage purposes, they need to be initialized. Each GPS receiver should only need to be initialized the first time the unit is used, or if it has been stored for several months or moved a substantial distance while turned off. The initialization procedure is automatic for most GPS receivers and begins on power-up. To initialize a unit for the first time, take the GPS receiver outside with a clear, 360 degree field of view and turn it on. Navigate

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through the "pages" of the GPS using the LCD display until the unit shows that it is acquiring satellites. The unit will begin acquiring fixes on available satellites, and storing the orbital data for each in an almanac in memory on the unit. This setup should complete the initialization of the unit.

All GPS units **MUST** have their Wide Area Augmentation System (WAAS) enabled or turned on. When enabled, WAAS corrects for GPS signal errors caused by ionospheric disturbances, timing and satellite orbit errors (all crucial to GPS accuracy), as well as providing vital integrity information regarding the health of each GPS satellite. GPS positional accuracy can be significantly better with WAAS enabled, then when this feature is not on. The WAAS system consists of a number (~25) of ground reference stations positioned across the United States that monitor GPS satellite data. Two master stations receiving all of this data are used to create a GPS correction message, which ultimately is broadcast through one of two geostationary satellites and can be read by any WAAS-enabled GPS receiver.

To enable WAAS on a GPS unit, simply navigate to the main Menu screen. From here, you should be able to identify a Setup option. Most GPS units (and ALL Garmin GPS Units) have a General tab provided in the Setup Menu screen. Simply click on the WAAS option and choose from ON/OFF or Enable/Disable. Choosing either ON or Enable, will provide the WAAS correction of GPS data, improving spatial accuracy across all GPS waypoints.

There are two key items to remember when using consumer-grade GPS units relative to coordinate data being saved/recorded: 1) coordinate information stored directly on the unit (as waypoints or routes) is always stored in a world geographic coordinate system (WGS84) datum and cannot be overridden until they are downloaded; and 2) you can override the datum and projection being displayed on the screen using the setup menu as necessary, <u>but it is important to document what you set the datum/projection to (i.e., NAD83 Stateplane Alaska Zone 1).</u> If recording those coordinates (i.e., latitude and longitude) onto a data form/book rather than saving as waypoints on the unit—this is imperative to ensure correct display in GIS for rendering final output.

For the reasons outlined above, all GPS units should be setup in the Menu options for acquiring and displaying GPS coordinates in WGS84 Datum, with a Decimal Degree format, which is often denoted as ***hddd.ddddd*** (or 58.12345, -135.12345) on GPS units, rather than in Degrees, Minutes, Seconds or an alternative. This provides consistency from observer to observer, as well as between different GPS units. Staff from the Region V "Habitat" Group will initialize and establish ALL GPS units being used by stock assessment crew members at the beginning of field seasons to ensure these parameters/options are programmed correctly.

Observers should always attempt to get the best possible "fix" from satellites when taking a GPS reading. Often, fixes with accuracy (or error, as it is labeled with some GPS units) under 15 m are possible in less than 30 seconds, especially on the larger river systems where canopy cover is minimal, and the view of the horizon is not obscured (e.g., high ridge immediately above river bank). There will be days when the constellation of the satellites is insufficient to allow for good fixes (i.e., >15 m accuracy); in these instances, it is preferred that GPS locations be acquired on a return visit, if logistically feasible.

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GPS Data Collection Procedures for use in Salmon Stock Assessment Projects

Juvenile Salmonid Coded-Wire Tagging Operations (Fall, Spring)

This section will describe the development and implementation of procedures and techniques for the collection of spatial data using GPS units at specific locations on the ground associated with smolt trapping sites on Transboundary River Systems. These projects include coded wire tagging (CWT) of Chinook and coho salmon pre-smolt and smolt which is a component of full stock assessment projects.

First and foremost, SF crews are NOT being asked to change their mode of operations, as it pertains to smolt trapping methods. Rather, the collection of spatial data using GPS units (waypoints) should be considered a task that occurs coincidentally with their delegated smolt trapping work. It should be noted that spatial data collection accompanying stock assessment activities can be scaled up or down, depending on staff and funding constraints, as well as project objectives. This "scaling" primarily relates to what features are being spatially located (trapping sites/areas OR individual trap locations). For example: identifying the extent of trapping sites/areas may only require one to several GPS waypoints to sufficiently delineate the entire Site/Area, even though there may be many traps spread throughout the Site; alternatively, if the objective was to spatially locate each and every trap within and across ALL trapping areas/sites, then a single GPS waypoint must be captured at each and every trap. Although the latter scenario requires more GPS waypoints (and associated data) to be captured (e.g., at each and every trap), the methods to accomplish this are implicit. However, the former scenario where the objective is to identify and delineate trapping areas/sites, may only require one to several GPS waypoints to adequately identify the extents of the entire trapping area. At this point, it should be self-evident that if crews were to capture GPS waypoints at ALL individual trap locations, that it would be possible to spatially locate each and every trap location (i.e., a single minnow trap), as well as very accurately identifying the extent (or trapping area/site) that each of the minnow trap locations is associated with. The following sections identify methods to be employed to address both of the scenarios (e.g., Trapping Area/Site Identification, and Individual Trap Locations).

Trapping Area/Site Identification

Generally, you will be looking to collect waypoints at smolt-trapping sites to generally describe the extent of the smolt-trapping area. For example, if we knew that trapping sites were all the same size and configuration, we could simply grab one waypoint for a group of traps known collectively to encompass site "X." However, the reality is that these trapping sites differ in size and configuration and migrate upstream/downstream or laterally, as water levels rise and fall across the trapping season. The general practice is that vernacular names are assigned to these trapping areas by stock assessment crews in a given season, and rather than re-naming those areas when traps are moved only short distances, they typically retain the same name. In other instances, SF crews move into new areas as snow/ice dissipate, at which time the area is assigned a new generic name.

Capturing waypoints in a manner that represents the whole extent or area of individual trapping sites can accommodate each of these scenarios. This may be as simple as taking single waypoints at small sites (which may represent 4–5 traps placed at a small log-jam) or as involved as taking multiple waypoints to accurately determine the boundaries of a relatively larger trapping site. It may also entail taking additional waypoints as a single trapping site is fished out and traps are "shifted" or moved upstream or downstream; field crews may decide to keep their generic site name, because it's in close proximity. One additional waypoint may be sufficient such that we would be able to map out the entire extent of the trapping area.

The bottom line is that multiple waypoints are collected at each site to generally describe the extent of the area being trapped. If two waypoints are collected for a single trapping area, generally identifying the upper and lower portions of the site and a few traps are below or above these waypoints by 20–30 meters, this is fine. We are looking for a precision of under 50 meters in most cases although 100 meters may be the best we can do in large braided areas of the floodplain, without unduly creating chaos for field crews where the primary responsibilities are trapping large numbers of fish. Appendix Figures 1–3 illustrate the use of waypoints in delineating or "outlining" the extent of trap sites (areas) with an acceptable level of precision. In these figures, the polygons representing the trap sites (areas) may appear to be arbitrarily drawn, considering that although the points fall inside, they do not provide all the corners. We should note that stream banks and islands present obvious boundaries for the delineation of smolt trapping areas in absence of other information, and will be evaluated using aerial photography during delineation in the office to map the site extent. It should also be noted that GPS waypoints captured during CWT operations, reflect river conditions at that time, while we rarely have base layer imagery (aerial photography or other), which will depict the same conditions across multiple years/seasons.

If traps are placed in areas where no site name is given (especially locations where only one or two traps are placed), specific comments should include a concise description of the general location (e.g., on small tributary to mainstem approximately 250 m from the main channel or in beaver pond complex on west side of mainstem approximately 400 m from the main river channel). In general, observers should *always describe features as to right or left as if they were looking downstream (e.g., confluence right bank)*—in other words, "going with the flow".

Individual Trap Locations

If time and resources allowed, individual GPS waypoints would be captured at ALL individual trapping locations (e.g., one waypoint for one trap); this information would be provided along with the full suite of accompanying data, including:

- Site Name, if the individual trap falls within a "trapping area";
- GPS error/accuracy
- Effort (one trap)
  - Multiple traps that are placed within close proximity to each other (e.g., <15 m), do NOT require multiple GPS waypoints, due to the associated positional accuracy/error of the GPS waypoint
- Catch (how many fish were captured; multiple entries if > 1 species was captured);
- Brief description of habitat surrounding trap location

-continued-

From past collaboration efforts with stock assessment crews, where our intent was to identify and delineate the spatial extent of CWT areas, we have realized that the collection of data to this detail was above and beyond "standard" operating procedures for stock assessment crews, in pursuit of their own objectives. This led to varying degrees of extra time/effort, with minimal changes if staff members from the "Habitat" shop (i.e., those writing this document) were present and collecting the relevant information, to several minutes per site if only stock assessment staff were collecting the data.

We recognize the need to balance staff resources and time to meet the primary objectives of stock assessment projects. Therefore, we propose methods which will have the LEAST impact upon stock assessment crews, sacrificing the additional information, which would be available if all of the additional information (those identified in bullets above) was collected. These methods simply call for a minimum number of GPS waypoints to be captured to spatially locate the extent of individual trapping areas, as opposed to individual traps, including "Catch" and "Effort" (See Appendix Figures 1–3 for further details/explanations). There may be opportunities for "Habitat" staff to accompany stock assessment crews, which allow the full suite of accompanying data to be captured, without hindrance or constraint. In these situations, the Habitat staff will collect all relevant information, while accompanying stock assessment crews during their normal activities.

General Data Collection Protocols

There are general data collection protocols governing the capture of GPS waypoints, which should be employed regardless of the "scale" at which data is captured. These procedures are identified in the following paragraphs, and should be adhered to for BOTH: 1) Trapping area/site identification; and 2) individual trap locations.

The collection of waypoints associated with individual trap sites (areas) should accompany trap data in field notebooks used by research staff. This would include recording the GPS Model/Make, assigned Unit letter (e.g., L, M, N, etc), the waypoint number, the GPS positional error (or accuracy), and a very brief description of what the individual waypoint represents (e.g., upper most river right or lowest point on river left, etc). If only one GPS unit model is used by a crew throughout the smolt trapping season, then it will be unnecessary to record this information daily; just make sure the relevant unit information is on the first page of each field notebook used.

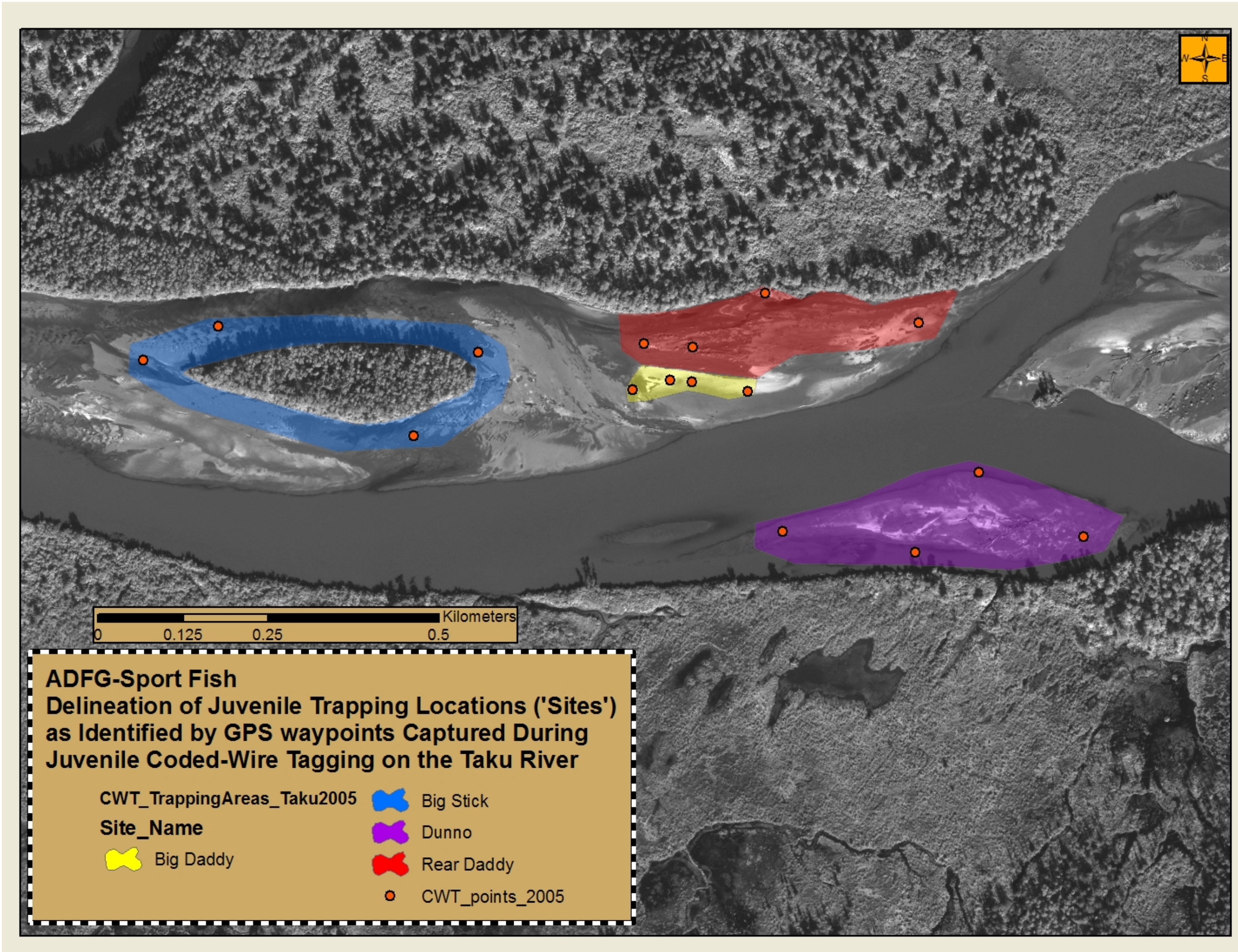
One additional piece of information to be recorded includes species and fish numbers. Past experience working with stock assessment crews during CWT suggests this information is NOT always recorded, as it is not a crucial component (i.e., "Required") of CWT operations; however, we have observed some field crew members recording this data, and therefore we present methods which would outline procedures for data collection. If this data is generally collected concurrent with checking trap lines, then it should be recorded in field notebooks. This information will accompany trap related records associated with the trap site (area), which field crews collect each day, such as number of traps placed, number of traps checked, number of fish, number of traps pulled, etc. An example of the data collected during smolt trapping which captures all the relevant GPS data is provided in Appendix Table 1. Note that if sites shift, field crews should take another waypoint on the day they are shifted or moved, which depicts the extension of the trapping area (site), and code this information in their field notebooks.

Appendix Table D1.–Example of data collected and recorded in the field during smolt trapping efforts on the Unuk River in fall, 2003.

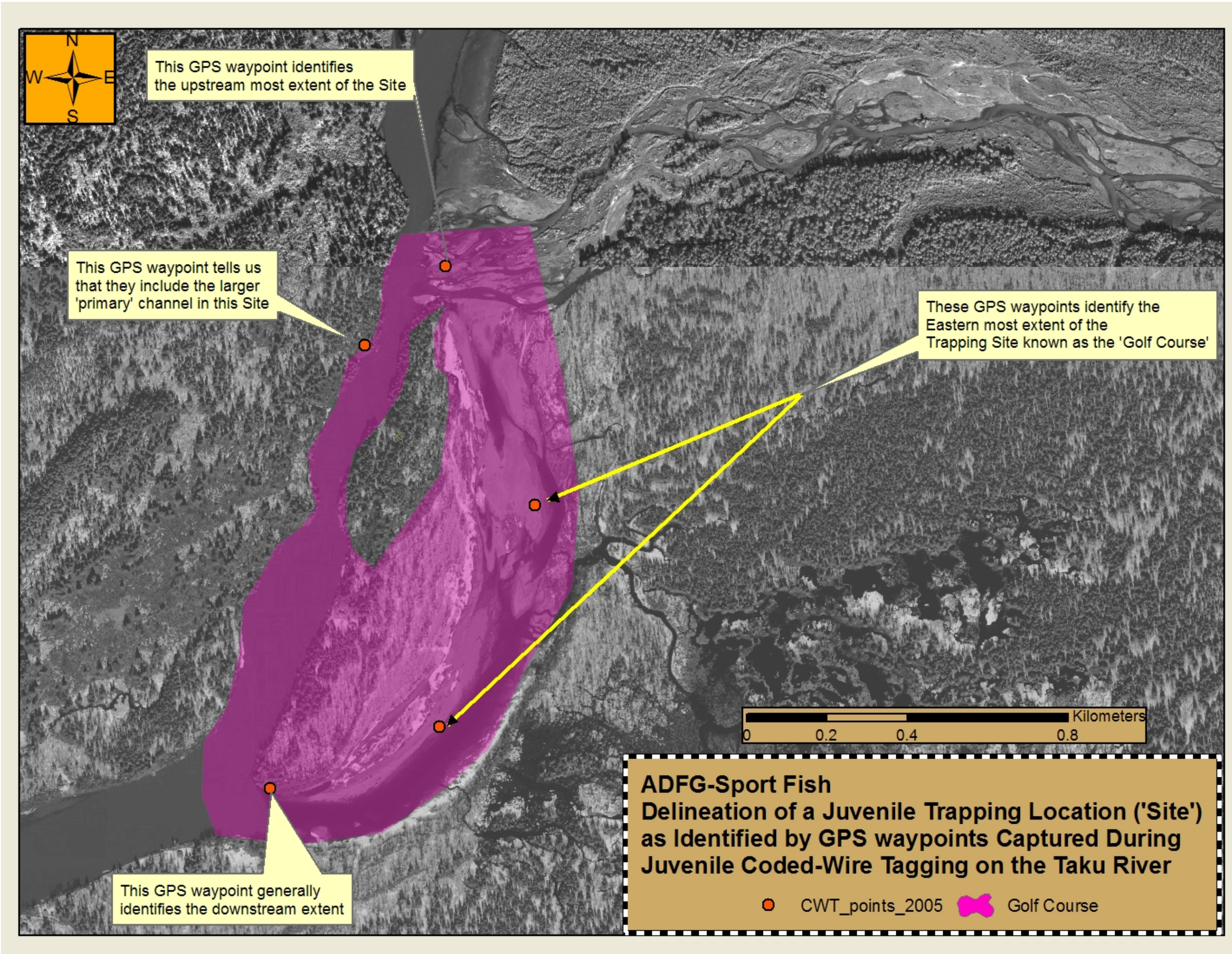
Date: 10/20/2003 GPS Unit Model: Magellan 320, (unit L)

Waypoint #	Waypoint Accuracy (m)	Traps set	Traps pulled	Traps checked	Total traps	SF Site	# of fish by species	Waypoint description
1-4	8, 11, 7, 15	12	0	12	12	Shotgun slough	220 coho;	1&2 - lowest most right/left bank;
							110 king	3&4 - upper most right/left bank
5,6	10; 10	10	0	10	10	Spaghetti flats	140 coho;	5 - upper;
							140 king	6 - lower
7,8	8, 12	6	0	6	6	Wolfkill	40 king	7- upper;
								8 - lower
9	13	0	4	4	0	Snowball	35 coho;	Center of trap area
							10 king	
10, 11	6, 9	0	6	6	0	Sanjay's channel	50 king	10 - upper;
								11 - lower
12, 13, 14	8, 7, 15	8	0	8	8	Dump cove	60 coho	12 - upper
								13 - central (right bank)
								14 - lowest
15	10	4	0	4	4	Backloop alley	20 coho	Central

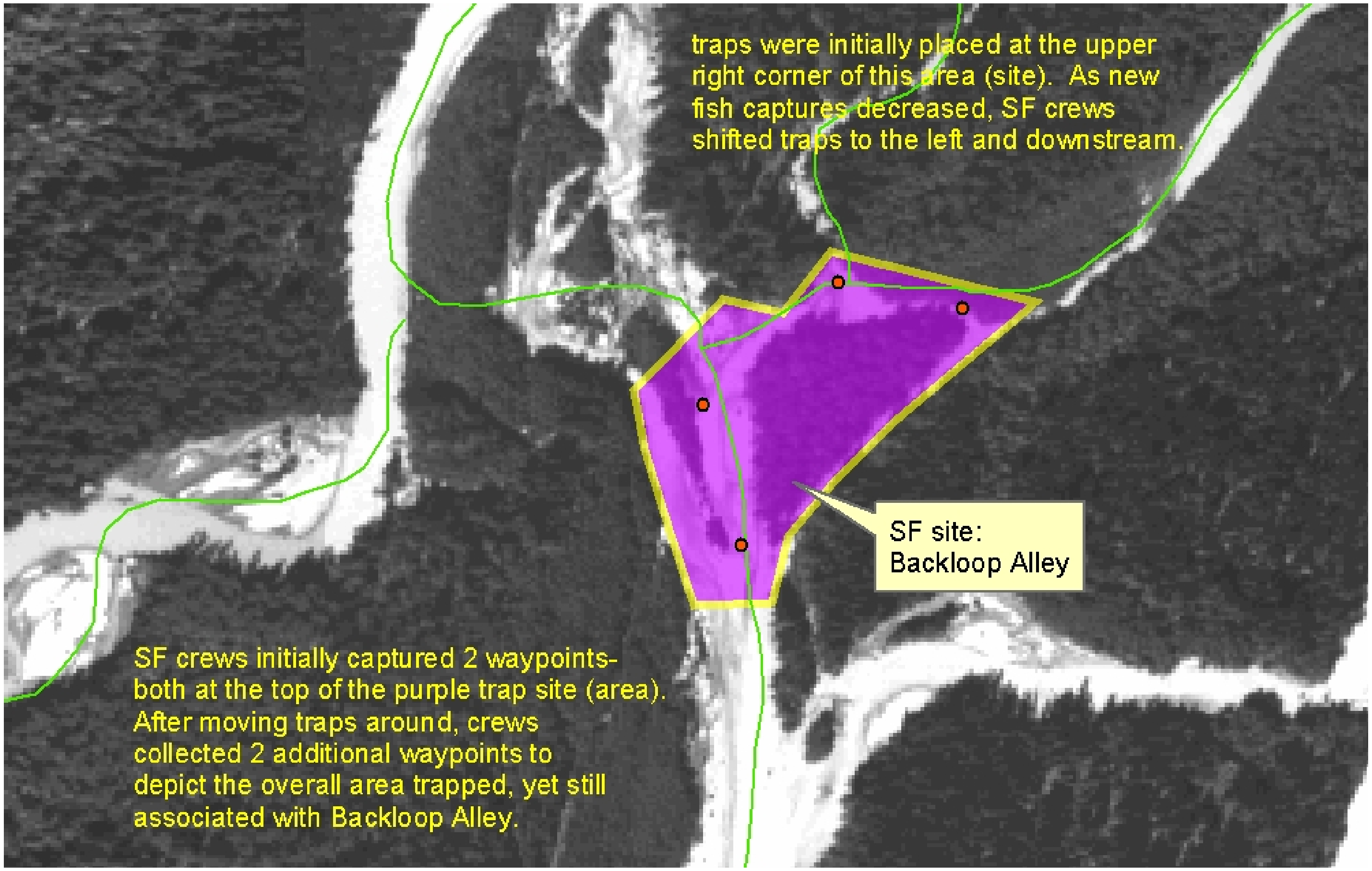
Note: In summary, coordinate data should be recorded at all CWT trapping sites where minnow traps are deployed. As an alternative to recording GPS coordinates at each and every minnow trap being deployed, observers can define the bounds of the area being trapped (e.g., Spaghetti Flats, six-pack slough). If a site is fairly confined or constrained (e.g., has a defined upper and lower end such as a slough) then 1–2 waypoints should be taken at the upper and lower extents of the upper portion and additional waypoints as necessary taken at the extents of the lower reach. Trapping observations recorded in "smolt trapping data books" should include the saved waypoint number(s), and include vernacular name assigned to that particular site.



Appendix Figure 1.–Delineation of four juvenile salmonid trapping areas (i.e., "Sites") on the Taku River, as identified from GPS waypoints captured during 2005 stock assessment activities. The outlined polygons represent four single trapping areas (Sites). Individual trapping sites may contain an infinite number of traps. The orange dots represent waypoints collected to sufficiently delineate the "approximate" extent of trapping effort associated with this site.



Appendix Figure 2.–Using more than two waypoints to delineate the extent of the trap site "*Golf Course*" on the Taku River. The upper and lower most waypoints are critical, although the 3 other points allow us to more accurately represent traps that were placed on both the river left and right side of the island.



Appendix Figure 3.–Example of expanded trap site, and GPS locations used to document that site as local conditions changed due to changing trap catches, and rising and falling water conditions on the Unuk River, Alaska. Again, SF crews shifted traps in response to decreasing numbers associated with initial trap locations (upper portion of polygon). Rather than re-name the SF site, they elected to capture two more waypoints associated with new trap locations thereby providing four "corners," where we could delineate the Backloop Alley trap site (area).

Adult Salmonid Escapement Sampling (Mark-Recapture, ASL)

This phase of the work will lay out a protocol for collecting GPS data associated with adult salmon stock assessment research. The methods/protocols outlined below will specifically address the "Habitat Group's" involvement with the activities associated with adult mark-recapture work primarily conducted on spawning grounds.

Marking Event

GPS data will be recorded during **marking events** at all set gillnet sites (if appropriate, depending on river and adult methods employed) or at any location where fish are being marked and released as part of the experiment. Note that only one GPS reading needs to be recorded at each set gillnet site (if the site does not change), or marking location, assuming an acceptable fix was acquired (<35' accuracy). Observers should take the reading from either side of the cork-line (for set gillnet sites) or from a central location associated with "marking" stretches of rivers. Please record whether the waypoint is associated with set gillnet sites or marking locations for the respective record(s).

Recapture Event

Because sampling during the **recapture events** may focus on spawning reaches rather than distinct sites, the acquisition of GPS data points that are meaningful will be strongly influenced by several factors. Most notable, will be the comments that are recorded along with GPS waypoint information. These should be explicit, identifying for example, the upper and lower points of a spawning riffle, general habitat characteristics, and other reasons why individual waypoints were collected. Because a variety of gear is used for recapturing adult salmon, record the specific type either on the header of the data form, or in the comments field; knowing that habitat features may limit the effectiveness of certain gear for sample collection purposes.

Obviously, it would be impractical to take GPS coordinates for each individual adult on the spawning grounds. However, every attempt should be made to gather this information in habitat with large congregations of fish. Because it is difficult to qualify what large congregations of fish might constitute, the burden will lie with each observer to recognize potentially important or distinct reaches of habitat that are being utilized by more than one or two salmon. There may be exceptions to this general rule, as some tributaries that are surveyed inherently have smaller numbers of fish; in these instances, observers should rely on a common sense approach drawing on his/her own experience as to when to take coordinate data. H&R staff will expand on this particular point when presenting their goals at the orientation meeting and hopefully, again in the field when adult salmon move onto the spawning grounds. It should be understood, that observers can take an infinite number of geo-referenced data points all of which correspond to biologically meaningful locations. **GPS data points are meaningless however, unless accompanied with a description of what the waypoint is associated with (which should be addressed in the Comments field—see Appendix Table 2).**

If individual marked fish are encountered, it would be prudent to gather GPS data associated with the exact location—especially when in conjunction with a larger congregation. This information can be used to display the distribution of tagged or marked salmon in relation to original point of marking (for movement patterns) across a watershed. Additionally, GPS waypoints could be acquired for locations where salmon that were fitted with radio transmitters were re-sampled on the spawning grounds, to gain additional fixes.

Appendix Table D2–Example layout of data form that could be used while collecting data from adult salmon during stock assessment research projects in Southeast Alaska. Note that fields included are directly off of the salmon stock assessment project on the Unuk River, Alaska.

Way#	Fish #	Date	Sex	MEF	Age	AEC	Spag tag	Adipose clip/cinch	UOP	LAA	Card #	Comm

Foot/Boat Counts

Foot surveys associated with salmon escapement data collection are conducted routinely on key index systems across Southeast Alaska for Chinook, sockeye, coho and steelhead. Often times, surveys are performed from a known starting point and proceed to some known stopping point in an effort to ensure the ability to do comparisons across years. In addition, more than one survey is typically conducted in these index areas across the season to evaluate whether or not a "peak-count" has been achieved. However these types of surveys typically have not included a spatial component (GPS coordinates) for integration with GIS for later assessments as it relates to project specific objectives as well as other research and assessment needs (e.g., landscape modeling to predict locations of critical spawning areas).

In most cases, foot surveys begin at the downstream end of a stream or river and proceed upstream to some predetermined stopping point (as is the case in "Coho Index Streams"). Fish are counted along the course of the survey while transiting from point-A to point-B, and the resulting numbers observed recorded on the corresponding data form or notebook.

While it is not required to employ a GPS while doing these types of survey, it is highly recommended. A GPS point (waypoints) should be recorded and saved on the unit at the start of the survey, and subsequent waypoints collected to document key features and fish observations along the way. It is also important to record the activity the fish was involved in during your observation because observing actively spawning adult salmon is likely more specific and important than a school of adult salmon holding in the middle of a pool. Appendix Table 3 illustrates a possible layout for a data form that can be used to capture spatial data associated with foot survey data.

Appendix Table D3.–Example layout of data form that accommodates spatial data collection while conducting foot surveys. Includes example data to illustrate a linear survey approach using GPS.

Waypoint #	Species	Hab_feature	Activity	Count	Comments
001		Start survey	--	--	--
002	KS	Pool	Holding	50	--
003	KS	Riffle start	Spawning	150	~30 spawned out + 10 dead
004		Riffle end	--	--	--
005		End survey			Survey stopped at barrier

Work Tasks – For Incorporation into Stock Assessment Operational Plans

1. Following protocols outlined in this document, capture GPS waypoints at all locations where a minnow trap has been placed (i.e., one GPS waypoint for every trap), except in the following circumstances:
    a. any traps placed within 20 m of each other, should have one and only one GPS waypoint captured (this minimizes field crew time as well as accounting for GPS positional error, which may be in the 15–20 m range)
        i. in these instances, crews should identify the TOTAL number of traps which fall into this 20 m proximity range, so that estimates of catch and effort are accurately recorded.
    b. any traps which are NOT moved after initial GPS waypoint capture, but which are continued to be "fished"
        i. in these circumstances, simply record the initial GPS waypoint number
2. On the ***ADF&G-SF Juvenile Salmonid Capture & GPS Datasheet***, capture and record the following data components for each GPS waypoint captured:
    a. GPS waypoint number
    b. **GPS positional error/accuracy** (in meters)
    c. **Number of traps - associated with the waypoint** (follow guidelines in 1a-i above)
    d. **Name of Trapping Area (Site)** of which the trap(s) are associated with
    e. **Catch** (total number of Chinook and Coho-(combined) captured)
    f. **LWD Presence (Y/N**) – this is the presence of Large Woody Debris, if associated with the trap; if multiple traps are associated with a single waypoint (per 1a-i above), provide this info individually (e.g., if three traps were associated with waypoint number 16, and two of these three traps were adjacent to LWD, record the following: Y=2; N=1)
    g. **Waypoint Descriptor -** Record the general location of the waypoint, in the context of the individual Trapping Area/Site (Column 4). These points are used to draw/delineate the boundaries of individual Trapping Areas/Sites. Use the following codes to describe the locations of individual waypoints:

        - TOA – Top of Area
        - BOA – Bottom of Area
        - COA – Center of Area
        - RRA – River Right most side of Area
        - RLA – River Left most side of Area

ADF&G-SF Juvenile Salmonid Capture & GPS Datasheet

Trap Line Upper/Middle/Lower)__________________________GPS Unit #___________Date____________________
Observers_______________________________Comments_________________________

Waypoint Number	Waypoint Accuracy (meters)	Number of traps	Name of Trapping Area/Site (e.g., Rear Daddy)	Catch (Total # of kings/coho combined)	LWD Presence (Y/N)	Waypoint Descriptor (see Cheatsheet)	Comments

APPENDIX E: DATA ARCHIVE FILES

Appendix E.–Data files generated during project, 2007–2008, in the Taku River watershed, Southeast Alaska. Data files (*.shp) archived at Alaska Department of Fish and Game, Division of Sport Fish, Southeast Regional Office, Island Center Building, P.O. Box 240020, Douglas, AK 99824-0020.

File	Description
TRH_ProjectArea.shp	GIS polygon shapefile (ArcMap 10; NAD83 State Plane, FIPS 5001 projection) containing project area delineation for the Taku River watershed.
TRH_watershed.shp	GIS polygon shapefile (ArcMap 10; NAD83 State Plane, FIPS 5001 projection) containing watershed delineation for the Taku River watershed.
TRH_FlightLines.shp	GIS polyline shapefile (ArcMap 10; NAD83 State Plane, FIPS 5001 projection) containing polyline delineation of all image acquisition flight lines.
TRH_PhotoCapturePoints.shp	GIS polyline shapefile (ArcMap 10; NAD83 State Plane, FIPS 5001 projection) containing point delineation of all image acquisition photo centers.
TRH_CWT_Points.shp	GIS polygon shapefile (ArcMap 10; NAD83 State Plane, FIPS 5001 projection) containing point delineation of GPS waypoints captured to delineate CWT trapping areas and extents for 2008.
TRH_CWT_TrapAreas.shp	GIS point shapefile (ArcMap 10; NAD83 State Plane, FIPS 5001 projection) containing polygon delineation and attribute data for all individual CWT Trap Areas and extents for 2008.
TRH_CWT_TrapLines.shp	GIS point shapefile (ArcMap 10; NAD83 State Plane, FIPS 5001 projection) containing polygon delineation and attribute data for the three CWT Trap Lines for 2008.