Status and Trends of Fish Habitat Condition on Private Timberlands in Southeast Alaska: 2007 Summary

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Final Report

(Alaska Clean Water Action Grant No: 08-R07)

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June 27, 2008

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ACKNOWLEDGEMENTS

The Sealaska Corporation and the Alaska Department of Environmental Conservation funded this research as a cooperative effort under the Alaska Clean Water Action Program (ACWA Grant No: 08-R07). We thank Ron Wolf, Michele Mets, Nathan Soboleff, and John Hillman (Sealaska Corporation) for contract management and overall project support. Special thanks to the project field crew: Bernard Romey, Isaac Cadiente, Joanna Stodden, and Luke Knowles for their enthusiastic assistance in gathering field data. Keith Skaflestad and Max Dicks (Teckk Outfitters and Charters) provided boat charter services in Hoonah, and Scott Ownbey (Shinaku Charters) and Steve Lemire (Lemire Charters) provided boat charter services in Craig. Thanks to Ted Hitzroth (International Forestry Consultants, Inc.) for map production and GIS services. Interagency review was provided by the Alaska Department of Natural Resources Division of Forestry, Alaska Department of Natural Resources Office of Habitat Management and Permitting, Alaska Department of Environmental Conservation, and US Fish and Wildlife Service.

EXECUTIVE SUMMARY

In 1992 the Sealaska Corporation and the Alaska Forest Association initiated a monitoring program to examine the effectiveness of riparian buffer zones on private timberlands to protect fish habitat. This program included monitoring studies between 1992 and 1997 that addressed riparian stand composition, channel morphology, fish habitat, large woody debris (LWD), stream shading, spawning gravel sedimentation, mass wasting, and sediment supply. During 1998 to 2001, the program expanded cooperators with the addition of the Alaska Departments of Environmental Conservation and Natural Resources through the Community Water Quality Grant program. The research shifted from routine monitoring of fish habitat conditions to studies of windthrow effects on LWD supply in buffer zones and LWD recruitment and transport mechanisms in streams. In 2003 to 2007, the fish habitat and channel conditions monitoring program was resumed by the Sealaska Corporation in collaboration with the Alaska Department of Natural Resources through the Alaska Clean Water Action Grant program. Data were collected at previously surveyed reaches and at new reaches that were added for status and trend monitoring. In 2007 we repeated data collection at selected old and new trend monitoring study reaches to expand the status and trend monitoring program. This report presents the data that were collected during the field surveys in 2007 and the trend analysis findings for the new monitoring reaches. A schedule for future trend monitoring is included.

1.0 BACKGROUND AND OBJECTIVES

The Alaska Forest Resources and Practices Act (Act) was amended in 1990, and the revised Forest Resources and Practices Regulations (Regulations) were adopted in 1993 (Alaska Department of Natural Resources [ADNR] 2000, 2003). The Act required that riparian buffer zones be retained along all streams with anadromous fish for the protection of fish habitat and water quality. The Regulations specified that resource management agencies and forest landowners were to conduct monitoring to evaluate the effectiveness of best management practices (BMPs) to protect public resources.

In 1992 Sealaska Corporation and the Alaska Forest Association initiated a monitoring program to examine the effectiveness of riparian buffer zones on private timberlands to protect fish habitat. This program included monitoring studies between 1992 and 1997 that addressed riparian stand composition, channel morphology, fish habitat, large woody debris (LWD), stream shading, spawning gravel sedimentation, mass wasting, and sediment supply (Pentec Environmental, Inc. 1994, 1995, 1996a, 1996b; Martin et al. 1998; Perkins 1999). During 1998 to 2001, the program expanded cooperators with the addition of the Alaska Departments of Environmental Conservation and Natural Resources through the Community Water Quality Grant program. The research shifted from routine monitoring of fish habitat conditions to studies of windthrow effects on LWD supply in buffer zones and LWD recruitment and transport mechanisms in streams (Martin 2001; Martin and Benda 2000, 2001; Martin and Grotefendt 2001, 2005, 2007). These studies established a large network of buffer zone monitoring sites and contributed new information that improved our knowledge and understanding of buffer zone characteristics, LWD recruitment, and the fate of LWD in streams.

In 2003 the fish habitat and channel conditions monitoring program was resumed by the Sealaska Corporation in collaboration with the ADNR through the Alaska Clean Water Action Grant program (Martin and Shelly 2004, 2005, 2006, 2007). Data were collected at previously surveyed reaches and at new reaches that were added for status and trend monitoring. An analysis of habitat trends was performed for a subset of reaches that had multiple years of monitoring data and were suitable for trend analysis. These data were divided into two analysis groups: those with data only post-harvest and those with data pre- and post-harvest. The results of this analysis changed with each successive year of monitoring data. Following 2003, no significant trends were detected. After 2004, we found significant trends in habitat conditions were emerging for some habitat variables at both the post-harvest and pre- and post-harvest study sites. In addition, the results suggested that the full impacts of logging on habitat may not be observed initially after timber harvest; rather habitat responses are occurring over time (delayed response) and are predicted to continue into the future. The magnitude and duration of habitat response after logging are unknown at this time. Therefore, continued monitoring is needed at the existing and newly established study sites to document and examine the post-harvest response trends. A long-term strategy for trend monitoring using a pulsed sampling approach (Bryant 1995) was developed during 2005 to facilitate trend monitoring in a cost-effective manner. In 2006 we initiated the pulse monitoring strategy, which was continued in 2007 (see Martin and Shelly 2006).

In 2007 the objectives of the monitoring program were as follows:

1. Continue the status and trend monitoring of fish habitat conditions that was initiated by the forest industry during the 1990s.

2. Collect pre-harvest data for a subset of long-term trend monitoring study reaches to establish a baseline for future post-harvest comparison.

3. Continue data collection at a subset of existing long-term trend monitoring study reaches to maintain continuity in the long-term record.

4. Document the 2007 findings in a data report and provide a temporal context for using these data in future analyses.

This report summarizes the data that were collected during the 2007 field season and presents an initial evaluation of habitat trends for the pre-harvest data from the new monitoring reaches.

2.0 STUDY AREA

In 2007 we repeated data collection at the 13 study sites that compose both old and new (established in 2003-2004) trend monitoring study reaches. The survey reaches were located in three basins in the Hoonah area and in seven basins in the Craig area (Figure 1). Most of the reaches in both areas were MM channel type (Table 1). Only the Eagle and Coco study reaches occurred in timber harvest units with buffer zones on both sides of the stream. We surveyed these reaches to maintain continuity for the long-term record. Timber harvest adjacent to four of the new study reaches (i.e., Fish Eye, Trocadero Sec 21 & Sec 26, View Cove) occurred prior to our summer survey. Selected timber harvest by helicopter occurred at two reaches and conventional harvest was in progress near Trocadero Sec 21 and Sec 26. Buffer strip widths at the Trocadero reaches were generally greater than 20 m and only occurred along portions of the survey reaches. Because logging is in progress near both Trocadero study reaches, the final configuration of the buffer strips and harvest units is unclear at this time. Timber harvest is proposed for Game 8, Gartina 2, and Hetta during 2008 or 2009 (see Section 6.0 Future Monitoring). No harvest is currently planned for Gartina 1b and Estrella. The locations of the study reaches within each basin and the locations of timber harvest units and roads are shown on basin maps in Appendix A.

Table 1. Physical characteristics, timber harvest period, and survey history at 2007 study reaches.

Stream reach	Reach length (m)	Channel width (m)	Channel type[a]	Buffer zone present	Harvest period	Year first surveyed	No. of surveys
				Hoonah Area			
Eagle 1	931	13.3	MM	2 sides	1992-93	1994	9
East Eagle 1	327	6.3	FP	2 sides	1992-93	1994	8
Game 8	215	4.9	MM	unlogged	none	1997	5
Gartina 1b	294	4.9	MM	unlogged	none	2003	5
Gartina 2	281	6.6	FP	unlogged	none	2003	5
				Craig Area			
Coco 1a	436	8.8	MM	2 sides	2002	1994	9
Coco 2a	330	6.2	MM	2 sides	2003	1994	9
Estrella 1	522	14.1	FP	unlogged	none	1995	8
Fish Eye 1	439	9.9	MM	helicopter	Sp 2007	2004	4
Hetta 1	358	10.2	FP	unlogged	none	2004	4
Trocadero Sec 21	347	7.8	MM	in progress	2007-08	2004	4
Trocadero Sec 26	260	8.6	MM	In progress	2007-08	2004	4
View Cove 1	312	7.0	MM	helicopter	Fl 2006	2004	4

[a] From Paustian et al. (1992)

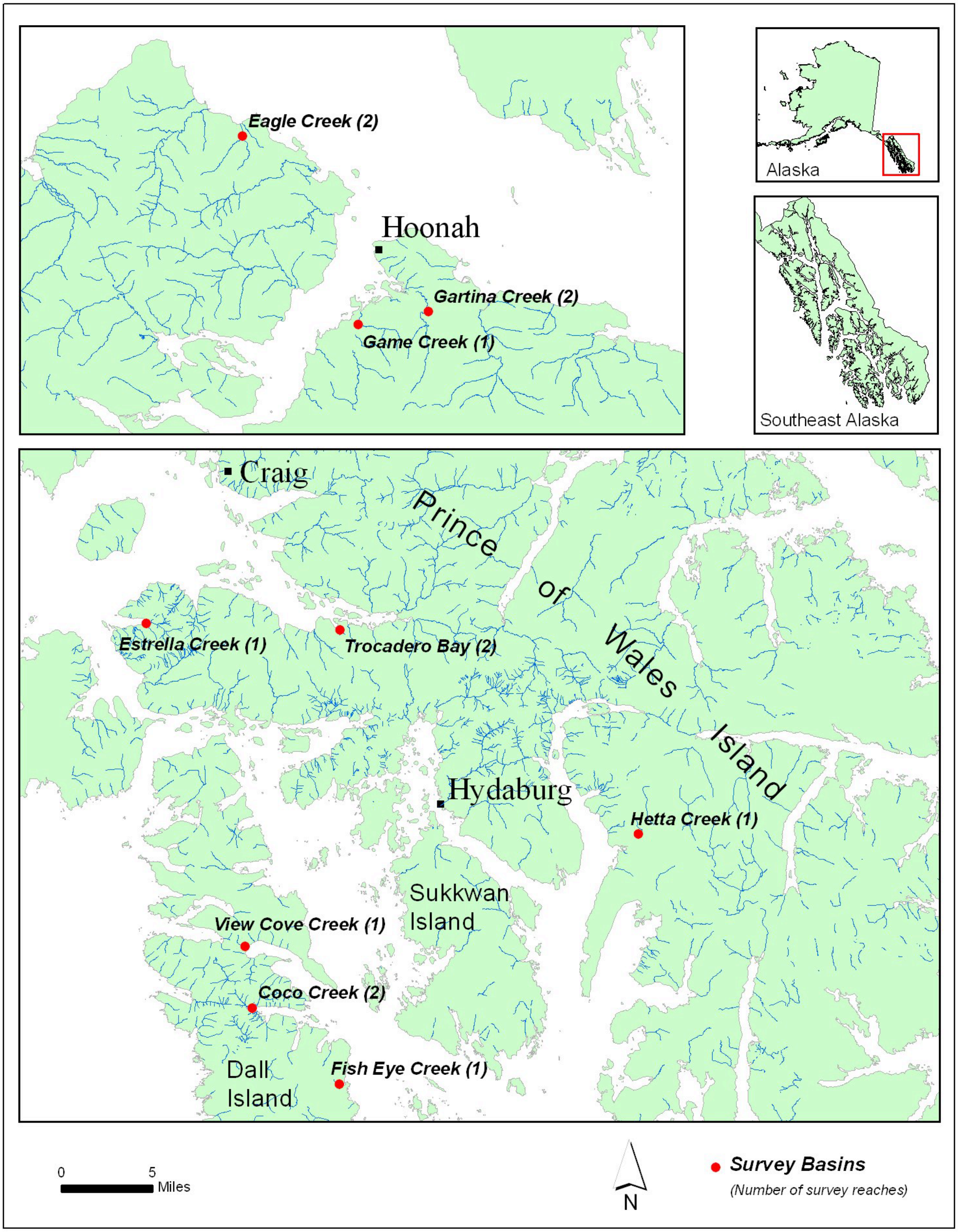


Figure 1. Location of stream basins that were surveyed during 2007. Number in parentheses denotes the number of stream reaches that were surveyed at each basin.

3.0 METHODS

3.1 FIELD SURVEY

Habitat measurements were taken from each channel unit (e.g., pools and riffles) within a stream reach. Channel units were defined by depth, velocity, and morphological characteristics similar to those described by Bisson et al. (1982). Channel units were stratified into main channel, associated unit, or off-channel categories. Units that contained the stream thalweg during summer base flow were defined as main channel units. Pools embedded within or adjacent to a main channel unit were categorized as associated units. Off-channel units included pools, ponds, or side channels that had a surface connection with the main channel and occurred within the active flood plain. Main channel and associated pools were further subdivided into primary pools and other pools based on the minimum area and minimum residual depth criteria defined by the Washington Timber-Fish-Wildlife Ambient Monitoring Program (Table 2).

Table 2. Minimum area and residual depth criteria for pools based on stream width (from Schuett-Hames et al. 1994).

Bankfull width (m)	Area (m^2)	Residual depth (m)
0 - 2.5	0.5	0.10
2.5 - 5	1.0	0.20
5 - 10	2.0	0.25
10 - 15	3.0	0.30
15 - 20	4.0	0.35
> 20	5.0	0.40

Habitat variables were computed from measurements of each channel unit. Unit length was measured along the centerline of the channel with a hip chain to the nearest 1 m, and the unit width (wetted) was measured to the nearest 0.5 m at two or three locations with a graduated rod. The product of unit length and mean width provided an estimate of wetted unit area. The percentage of habitat area for each primary pool type relative to the total wetted area of the reach was defined as the relative pool area (RPA). The percentage of the study reach length with primary pool habitat was defined as the relative pool length (RPL). Pool frequency was computed by dividing the number of pools in a reach by the reach length and standardized to 100 m. Pool spacing was computed by dividing the reach length, expressed in units of bankfull channel width, by the number of primary pools (including associated units) in the main channel portion of a reach. The number of channel widths in a reach was equal to the reach length divided by the mean channel width.

The tail crest and maximum depths of pools were measured with a graduated rod to the nearest 1.0 cm. The residual depth of pools (Lisle 1987) was computed from the difference between the maximum depth and the tail crest depth.

All LWD occurring either in the bankfull influence zone of the active channel (i.e., Zones 1 and 2 of Robison and Beschta 1990) or above the active channel (Zone 3 of Robison and Beschta

1990) was measured. LWD was defined as any piece of wood that was a minimum 0.1 m in diameter at the small end of the log and a minimum 2 m long. Each piece was assigned to a size group based on the estimated diameter at the center of the log: small (10-30 cm), medium (30-60 cm), and large (> 60 cm). During the 1998 and 2003 to 2007 surveys, the length of each piece was measured to the nearest 3-m interval; no length data were collected from earlier surveys. Piece volume was computed from piece length and diameter data using the geometry for a cylinder.

LWD was assigned to one of two location categories: pieces in jams or pieces located between jams. Jams were defined as LWD accumulations (two or more pieces) that block at least 20% of the bankfull channel width. Jam length (length of channel cover by a jam) and the length of interjam zones were measured with a hip chain.

LWD pieces that could be linked to their riparian location or source of recruitment were defined as recruits (i.e., recruits are a subset of LWD data). Recruits are pieces (usually whole trees) that are clearly attached to the adjacent bank (e.g., rooted to bank or trunk extending into riparian forest) or are contained in a slump/bank-slide deposit. All recruits were assigned a decay class using a modified version of a snag classification system by Hennon et al. (2002). Decay class was determined for the portion of a log that was on the bank or was least disturbed by stream flow. Decay classes were as follows: "green" (green leaves or needles retained), "twig" (twigs retained), "branch" (secondary branches retained), "primary" (only primary branches and some nubs retained), "nubs" (no branches and only nubs retained, and "old" (all advanced decay conditions including soft rotten and moss covered logs with dependent saplings growing on the bole). The green decay class included a small number of live trees where the bole was down in the channel and functioning as LWD.

Bankfull channel width (referred to as channel width [cw]) and substrate size composition measurements were taken at two to five stations located at riffle units within each survey reach. Channel width was defined by topographic breaks along the bank and by scour lines along the active channel edge where perennial vegetation gave way to mineral substrate on the streambed (Harrelson et al. 1994). Channel widths were measured to the nearest 0.1 m at riffles in straight and uniform sections of the reach that were free of hydraulic obstructions (e.g., logs, boulders, or bedrock). A pebble count (Wolman 1954) of 100 particles was taken on the riffle at each channel width measurement location to determine the bed material size composition. Bed material measurements were taken at one-step intervals along cross-channel traverses directly adjacent to the channel width measurement location. The d_{16} and d_{50} particle sizes were interpolated from a cumulative frequency distribution of the pebble size data as per Harrelson et al. (1994).

Photos were taken during each survey at each pebble count/channel width station to document channel position, bed and bank composition, channel disturbances, and LWD patterns.

3.2 TREND ANALYSIS

We performed trend analyses on key habitat variables at the new monitoring reaches for the 2003 to 2007 period. We defined trend as a consistent unidirectional change across all reaches. In statistical terms, repeat visits to reaches are repeated measures, for which there are several analysis options. We selected a profile summary approach, wherein the time series for each reach was summarized by one statistic: the linear least-squares slope estimate for the site. The significance of the regional trend was then assessed by comparing the average of the reach slopes to their empirical variance, using a t-test. Non-parametric tests were used instead of parametric tests if the distribution was significantly non-normal as judged by the Shapiro-Wilks goodness-of-fit test. For all tests we set alpha equal to 0.10 to minimize the risk of making a Type II error, as suggested by Bryant (2004). The null hypothesis tested was that the average trend among reaches for a given habitat variable was zero.

4.0 SUMMARY OF 2007 DATA

Summaries of LWD recruitment, LWD loading, pool characteristics, and substrate particle size are presented in Tables 3 through 7. All raw data are contained on a compact disc that was submitted under separate cover to the Alaska Department of Environmental Conservation.

In-channel recruitment of new LWD (i.e., green recruits) was observed at logged and unlogged monitoring reaches (Table 3). All but one of the logged reaches had new recruitment, including three of the four reaches (Fisheye, Trocadero Sec 21 & Sec 26) that were logged recently. New recruitment was also observed at two of the five unlogged monitoring reaches. The highest new recruitment occurred at both Trocadero study reaches, which had recent timber harvest adjacent to portions of the riparian area.

LWD loading densities and volume were highly variable among the study reaches (Table 4). The highest LWD loadings were more than double the lowest, and both the lowest and highest loadings occurred at unlogged reaches (i.e., Gartina 1b and Hetta). Jam frequency also varied several fold among the study reaches. The highest jam frequency was observed at Game 8, which has a small channel, and the lowest frequency occurred at Eagle 1, which has a large channel (Table 5). The inverse relationship between jam frequency and channel width is consistent with other data that we have collected (Martin and Benda 2001) and reflects the wood transporting potential of larger streams. Spacing between jams declines in the smaller streams, making it difficult to discern where one jam ends and another jam begins. Difficulties in delineating jam boundaries can affect the accuracy of determining jam frequency for smaller streams.

Pool frequency ranged from 1.8 to 8.2 pools/100 m, and RPA ranged from 7% to 57% (Table 6). Pool frequency and RPA are influenced by channel width, substrate size, and LWD loading (Martin and Shelly 2006). Therefore, general observations about logging effects on pools cannot be made without considering these natural controlling factors.

Streambed substrate surveys were performed at all but one of the cross sections at one study reach (Table 7). Excessive windthrow covered the cross section at Coco 2a Station 1150 and inhibited the pebble count survey. Substrate was dominated by gravel (i.e., 2-64 mm) and cobble (i.e., 64-256 mm) size material at all reaches. Sand (< 2 mm) and boulder (> 256 mm) size substrate were observed but were rare.

Table 3. Number of LWD recruits, recruit rate, and percentage of recruits by decay class for each stream reach during 2007.

	Recruits (no.)				Decay class (%)						
Stream reach	Above channel	In channel	Total	In channel recruits (no./100 m)	Green	Twig	Branch	Primary	Nubs	Old	In channel green (no./100 m/yr)
Coco 1a	27	44	71	10.1	12.1	27.3	12.1	3.0	3.0	40.9	0.69
Coco 2a	40	37	77	11.2	1.5	9.0	40.3	22.4	10.4	16.4	0.30
Eagle 1	35	80	115	8.6	5.6	10.2	6.5	12.0	22.2	43.5	0.43
E Eagle 1	35	41	76	12.5	15.8	25.0	6.6	10.5	21.1	21.1	0.92
Estrella 1	17	52	69	10.0	7.2	8.7	8.7	10.1	14.5	50.7	0.38
Fisheye 1	7	38	45	8.7	4.4	0.0	4.4	4.4	13.3	73.3	0.46
Game 8	15	30	45	14.0	2.4	0.0	0.0	11.9	35.7	50.0	0.00
Gartina 2	11	15	26	5.3	0.0	0.0	0.0	19.2	30.8	50.0	0.00
Gartina 1b	8	15	23	5.1	4.5	0.0	4.5	9.1	27.3	54.5	0.00
Hetta 1	22	43	65	12.0	1.7	0.0	11.7	3.3	16.7	66.7	0.28
Trocadero Sec 21	43	29	72	8.4	47.2	6.9	2.8	8.3	6.9	27.8	2.59
Trocadero Sec 26	7	30	37	11.5	33.3	2.8	0.0	0.0	8.3	55.6	3.08
View Cove 1	10	21	31	6.7	0.0	0.0	6.5	6.5	25.8	61.3	0.00

Table 4. LWD loading (number and volume) by stream reach during 2007.

	LWD pieces (no.)					LWD volume (m^3)				
Stream reach	Above channel	In channel	Total	In channel (no./100 m)	In channel (%)	Above channel	In channel	Total	In channel (m^3/100 m)	In channel (%)
Coco 1a	27	213	240	49	89	45.0	258.4	303.4	59.3	85
Coco 2a	40	204	244	62	84	58.1	186.5	244.6	56.5	76
Eagle 1	35	648	683	70	95	74.7	410.1	484.8	44.1	85
E Eagle 1	35	157	192	48	82	43.4	108.6	152.0	33.2	71
Estrella 1	17	397	414	76	96	26.1	441.0	467.1	84.5	94
Fisheye 1	7	179	186	41	96	8.4	135.9	144.4	31.0	94
Game 8	15	127	142	59	89	13.1	75.9	89.0	35.3	85
Gartina 2	11	129	140	46	92	10.1	106.1	116.2	37.8	91
Gartina 1b	8	104	112	35	93	8.0	58.5	66.5	19.9	88
Hetta 1	22	281	303	78	93	32.7	323.0	355.7	90.2	91
Trocadero Sec 21	43	182	225	52	81	49.2	148.4	197.6	42.8	75
Trocadero Sec 26	7	184	191	71	96	10.0	121.6	131.6	46.8	92
View Cove 1	10	152	162	49	94	9.8	106.5	116.2	34.1	92

Table 5. Number of LWD jams and jam frequency by stream reach during 2007.

Stream reach	Number of jams	Jam frequency (no./100 m)
Coco 1a	15	3.4
Coco 2a	8	2.4
Eagle 1	11	1.2
E Eagle 1	10	3.1
Estrella 1	14	2.7
Fisheye 1	10	2.3
Game 8	11	5.1
Gartina 2	7	2.5
Gartina 1b	6	2.0
Hetta 1	9	2.5
Trocadero Sec 21	11	3.2
Trocadero Sec 26	11	4.2
View Cove 1	10	3.2

Table 6. **Pool statistics for all primary pools within the main channel by stream reach during 2007.**

Stream reach	Number	Pool frequency (no./100 m)	Pool spacing (cw/pool)	RPA (%)	RPL (%)	Residual depth (cm) Mean	Residual depth (cm) Median	Residual depth (cm) Maximum
Coco 1a	19	4.4	2.6	34.0	29.8	47.9	45	110
Coco 2a	11	3.3	4.8	19.0	20.3	40.2	38	72
Eagle 1	17	1.8	4.1	11.5	15.1	49.4	47	75
East Eagle 1	21	6.4	2.5	46.6	50.2	41.7	37	71
Estrella 1	32	6.1	1.2	56.5	53.1	53.1	49.5	110
Fisheye 1	10	2.3	4.4	8.6	10.9	36.3	37.5	47
Game 8	15	7.0	2.9	24.2	26.5	32.5	29	55
Gartina 1b	13	4.4	4.6	32.1	31.3	33.4	31	61
Gartina 2	23	8.2	1.9	45.2	50.9	45.4	44	67
Hetta 1	23	6.4	1.5	30.5	36.0	50.3	44	94
Trocadero Sec 21	9	2.6	4.9	15.9	13.5	34.8	30	55
Trocadero Sec 26	8	3.1	3.8	15.5	16.2	49.0	46.5	92
View Cove 1	13	4.2	3.4	29.5	22.4	35.6	34	64

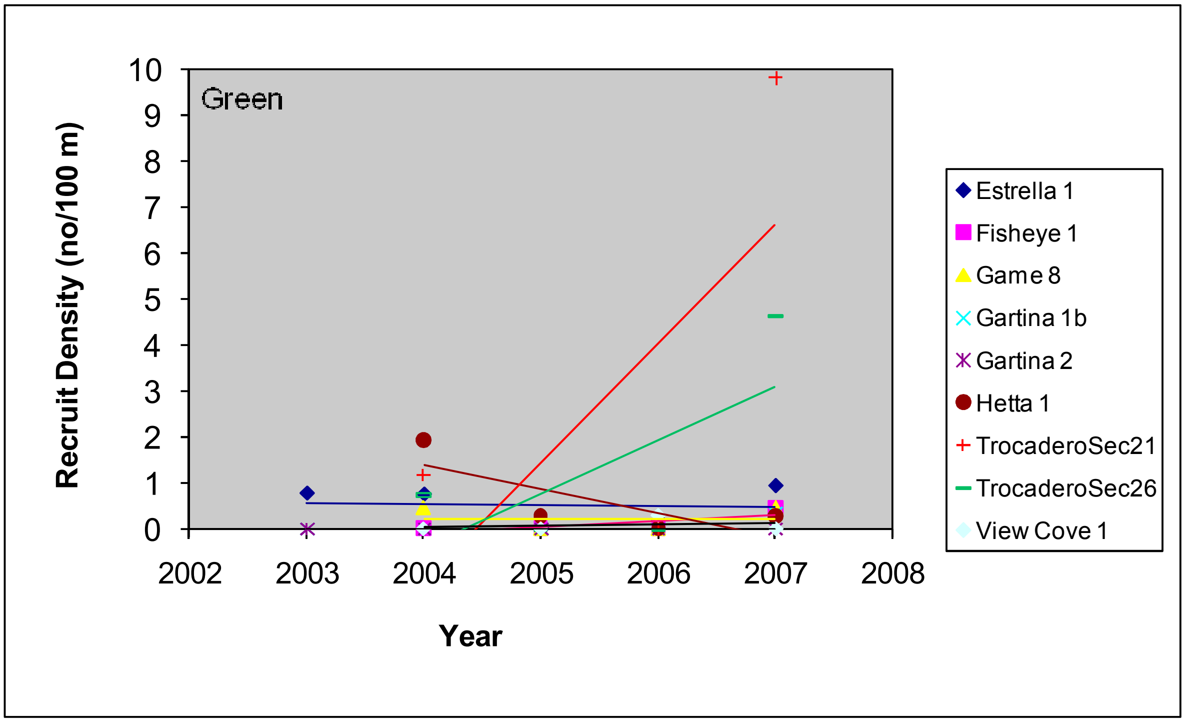
Table 7. Substrate particle size (mm) by location and stream reach during 2007.

Stream reach	Cross section no.	D_{16}	D_{50}	D_{84}
Coco 1a	47	7.4	22.6	57.4
Coco 1a	160	9.7	30.3	71.9
Coco 1a	305	11.4	35.0	80.6
Coco 2a	887	2.0	21.5	83.3
Coco 2a	950	16.3	38.7	85.8
Coco 2a	1060	14.2	47.6	109.4
Coco 2a	1150	windthrow inhibited survey		
Coco 2a	1220	17.6	44.5	154.2
Eagle 1	0	2.0	16.4	81.2
Eagle 1	170	8.6	37.8	95.1
Eagle 1	305	8.3	25.3	67.8
Eagle 1	474	11.3	36.9	116.9
Eagle 1	570	12.4	38.9	103.7
Eagle 1	715	6.7	47.2	134.1
Eagle 1	865	14.9	47.1	113.0
East Eagle 1	35	3.7	12.4	31.6
East Eagle 1	160	2.0	18.3	50.6
East Eagle 1	275	4.3	13.5	39.3
Estrella 1	0	4.7	13.7	29.4
Estrella 1	128	4.6	12.9	27.6
Estrella 1	300	2.5	12.7	45.9
Estrella 1	573	4.5	13.3	37.3
Fisheye 1	3	8.3	23.3	60.5
Fisheye 1	245	11.3	52.0	205.1
Fisheye 1	320	3.1	12.9	35.2
Game 8	73	10.7	31.2	95.1
Game 8	128	7.1	28.9	76.5
Game 8	202	7.7	23.7	85.9
Gartina 2	130	6.3	16.4	38.6
Gartina 2	205	5.5	17.8	37.9
Gartina 2	290	7.6	19.2	49.6
Gartina 1b	377	19.9	46.9	100.8
Gartina 1b	483	4.5	39.1	108.0
Gartina 1b	585	8.6	47.8	143.7
Hetta 1	76	8.5	21.9	51.0
Hetta 1	168	3.9	20.6	52.5
Hetta 1	275	11.6	29.1	74.9
Trocadero Sec 21	0	8.2	21.5	55.3
Trocadero Sec 21	135	10.0	30.6	89.9
Trocadero Sec 21	316	4.4	22.1	105.0
Trocadero Sec 26	0	10.8	32.0	96.5
Trocadero Sec 26	105	6.2	24.8	87.9
Trocadero Sec 26	255	9.1	21.5	64.0
View Cove 1	57	4.8	17.2	41.2
View Cove 1	135	6.1	14.7	33.4
View Cove 1	355	4.4	17.1	41.5

5.0 HABITAT TRENDS AT NEW REACHES

We did not find significant trends in habitat condition for most of the key variables at the new study reaches (see Appendix B for Trend Analysis Results). There was an increase in green LWD recruitment at both Trocadero sites in 2007, which is probably due to windthrow following the recent logging (Figure 2). However, no consistent increase or decrease in average green recruitment was detected for the nine new reaches when the recently logged sites were included (P = 0.172) or excluded (P = 0.437) from the analysis. Recruitment of twig-branch LWD was variable (i.e., some increasing and some decreasing), and no consistent trends were observed. The average density of in-stream LWD was increasing when the 2007 data from the recently logged sites were included in the analysis (P = 0.077), but no trend was detected when these data were excluded (P = 0.438; Figure 3). There were no consistent trends among sites for the pool variables (i.e., mean residual depth, median residual depth, RPL, and pool frequency) when all data were included in the analyses. However, when the 2007 recently logged data were excluded, we found a significant positive trend for pool frequency (P = 0.003) but not for any other pool variable (Figures 4 and 5). Exclusion of the 2007 Trocadero pool frequencies, which had declined relative to previous years, accounted for the change in average pool frequency that resulted in a significant trend. The average substrate size for both d_{16} and d_{50} categories was consistently declining over the past five years for all analysis groups (i.e., same result if the 2007 data from recently logged sites was included or excluded). Only a few monitoring stations at Game 8 and Gartina 1b had increasing substrate size trends during this period (Figure 6).

The increased green LWD recruitment at recently logged sites has increased variability for some habitat metrics and influenced the detection of general trends. Since this logging is ongoing at some of the sites, we expect to see more changes over the next few years. This shift in habitat condition is consistent with our earlier observations of post-logging responses (Martin and Shelly 2006). The decline in substrate particle size at nearly all of the new study sites, including those with no logging, is also consistent with our observations at other monitoring sites (Martin and Shelly 2006). This consistent decline in d_{16} and d_{50} suggests that the trends may be responding to a region-wide process (e.g., storm frequency) that needs further examination.



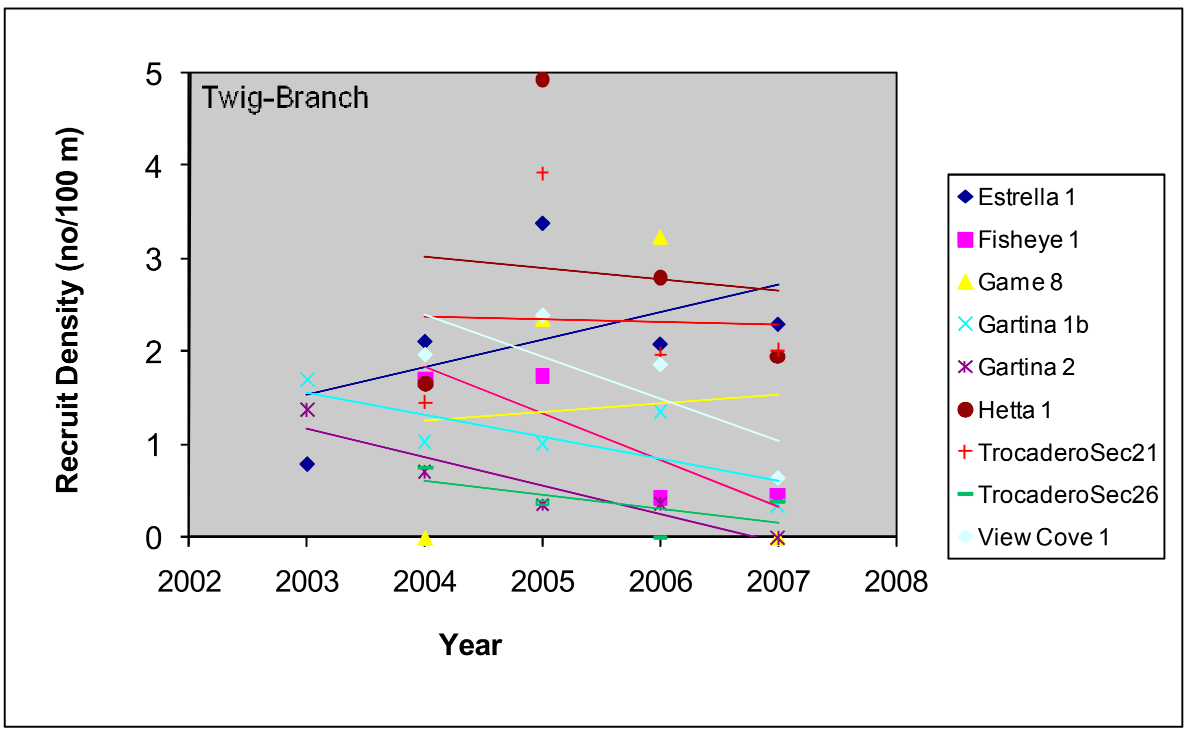


Figure 2. **Trends in LWD recruit density for green and twig-branch decay classes at the new monitoring sites.**

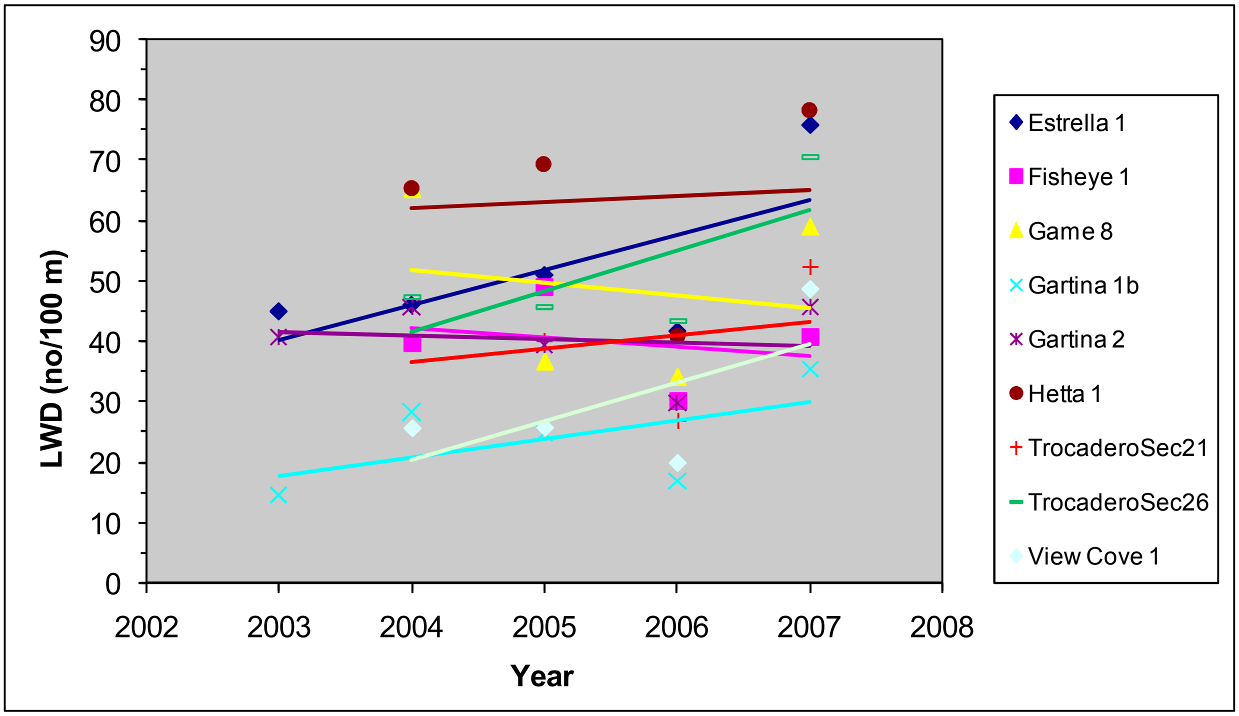
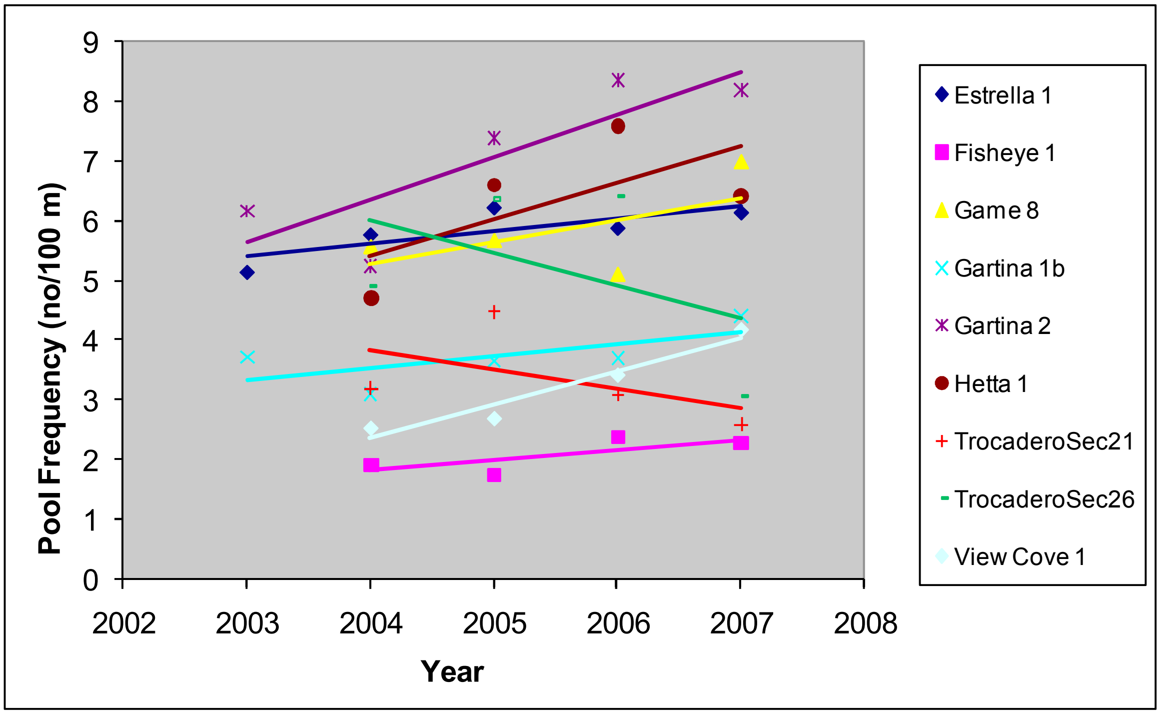


Figure 3. **Trends in in-stream LWD density at the new monitoring sites.**



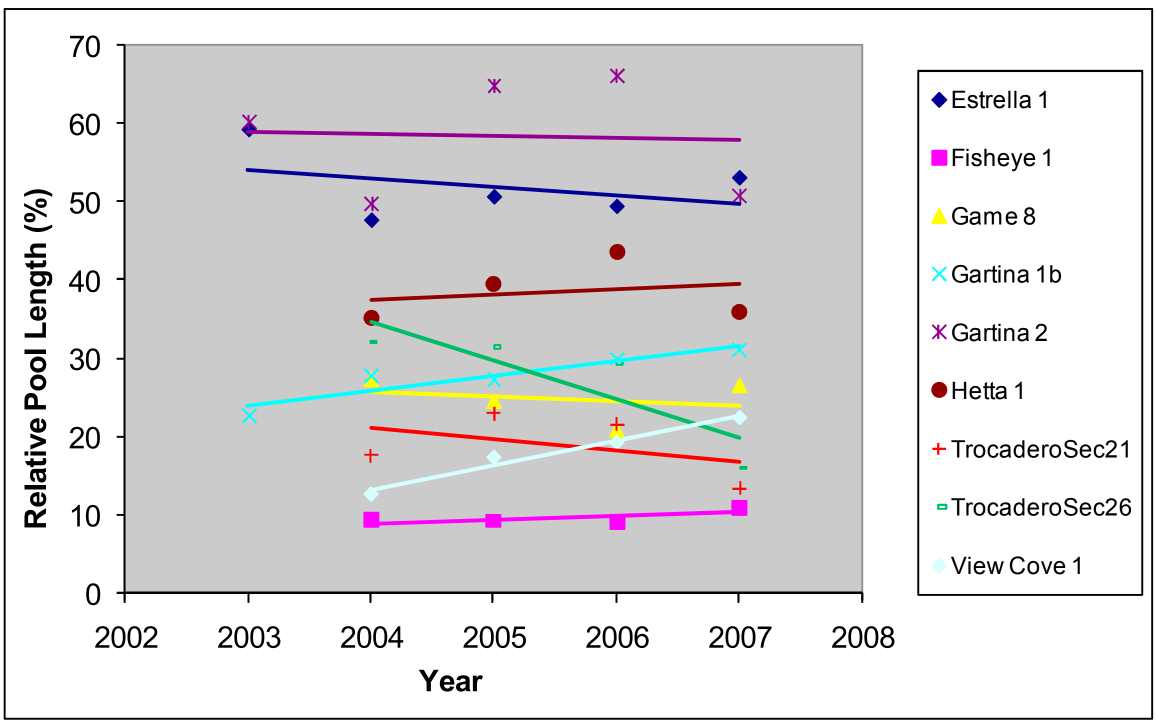
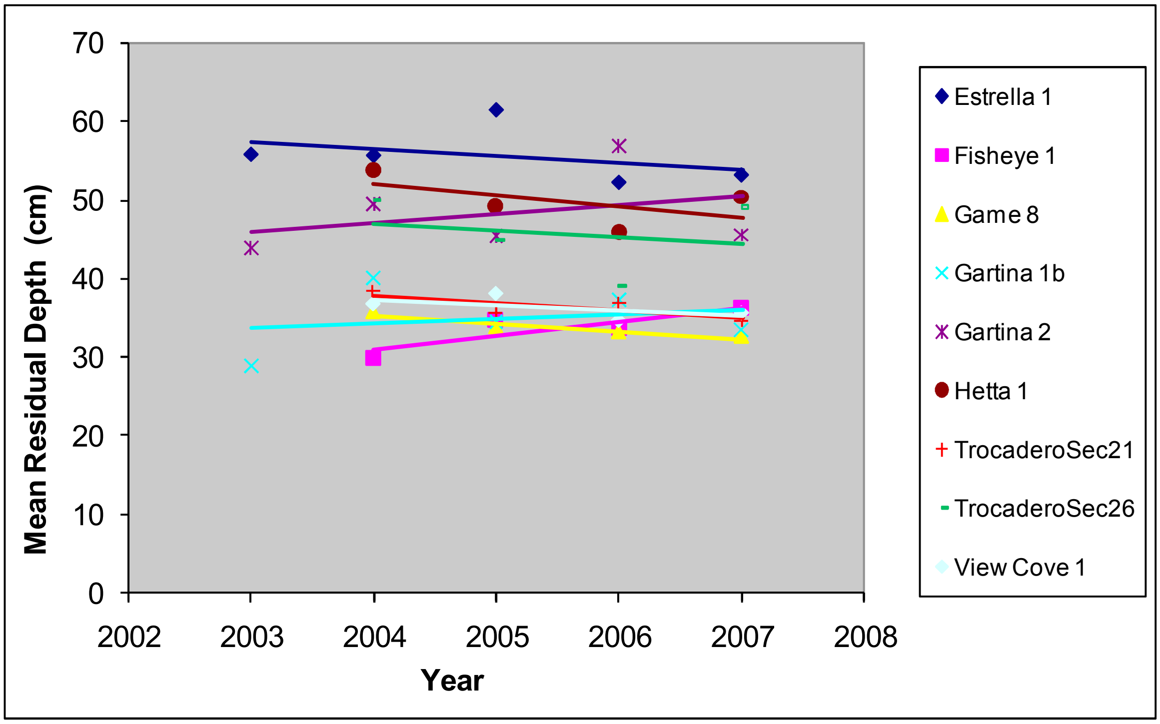


Figure 4. Trends in pool frequency and relative pool length at the new monitoring sites.



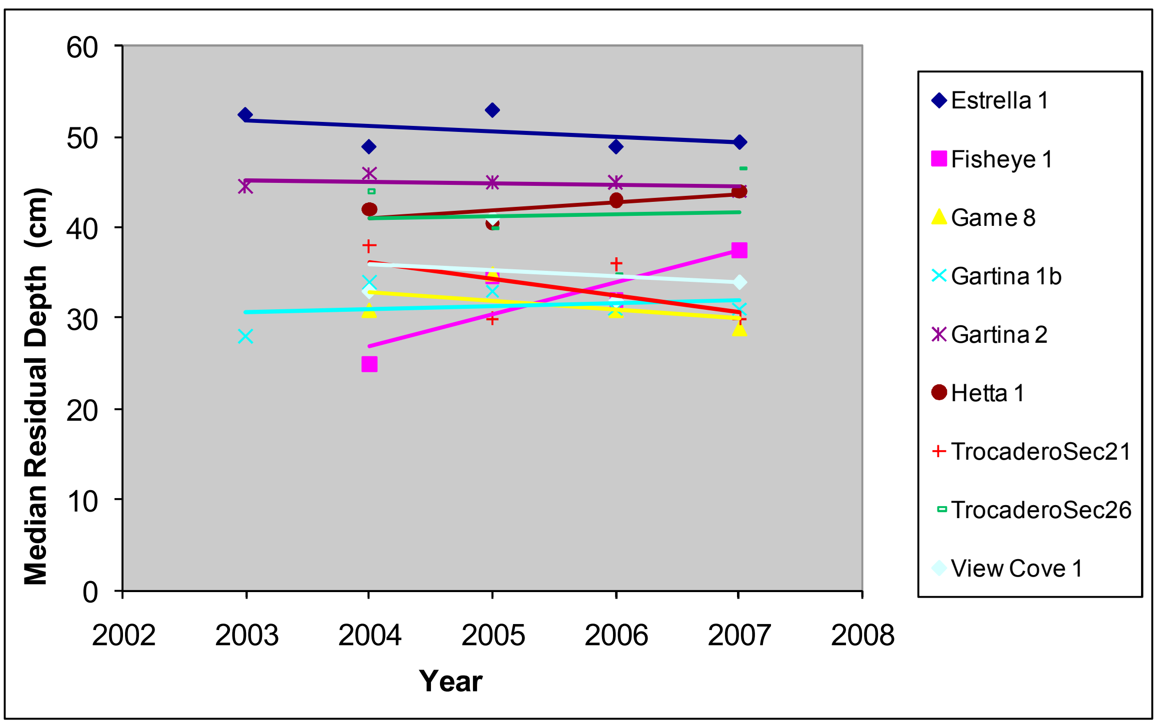


Figure 5. Trends in mean and median residual pool depth at the new monitoring sites.

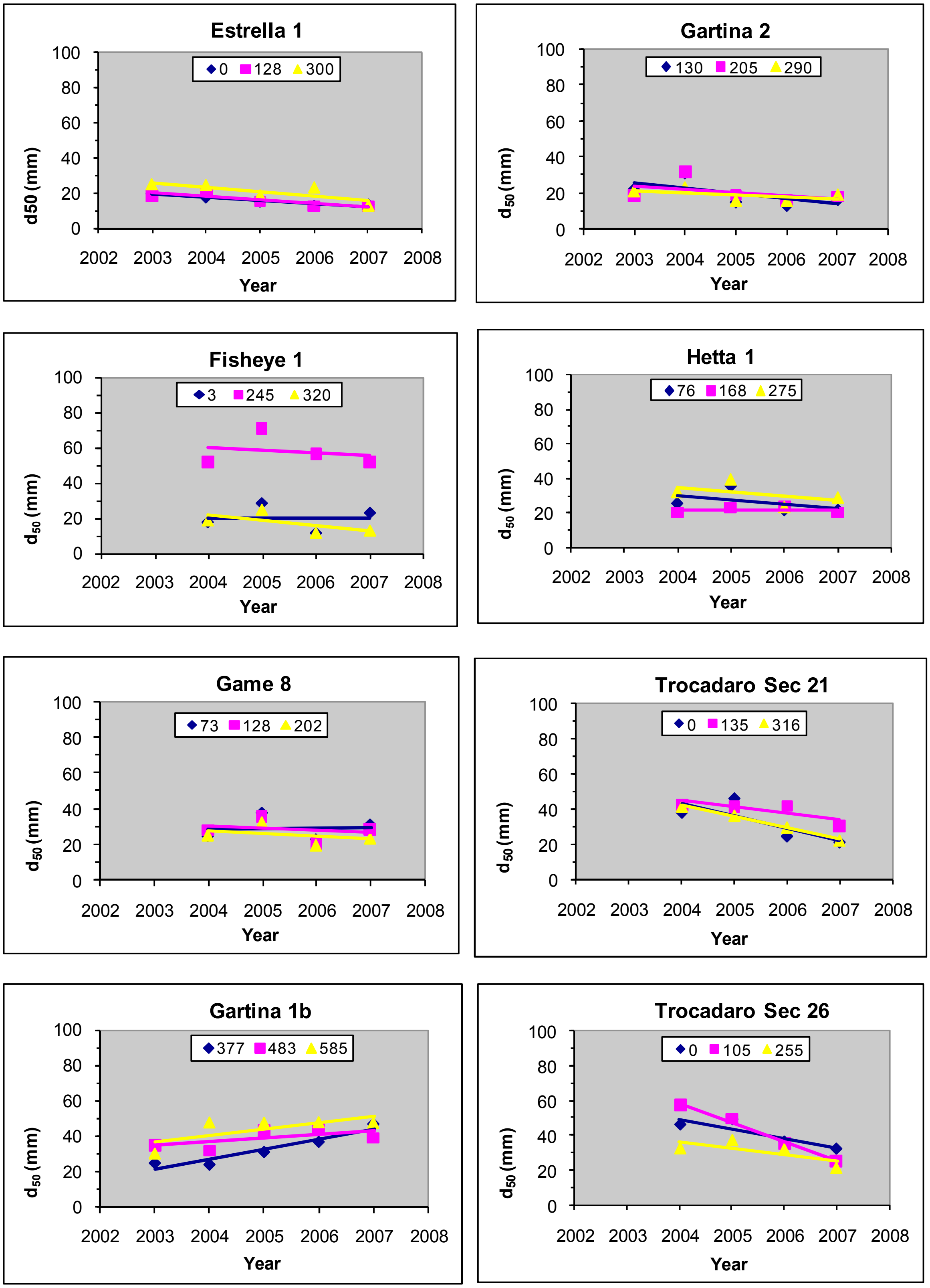


Figure 6. **Trends in substrate size d_{50} at the new monitoring sites.**

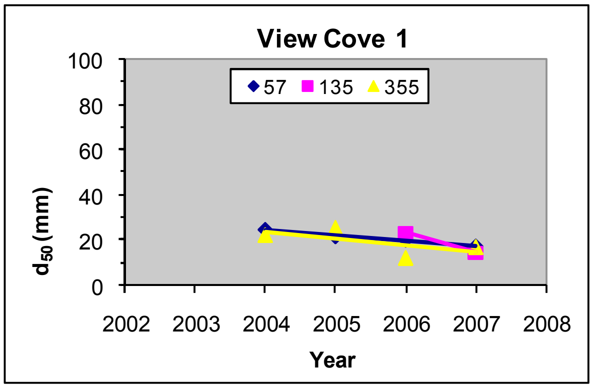


Figure 6. **(continued).**

6.0 FUTURE MONITORING

Over the past several years, we shifted to an alternating (pulsed) monitoring schedule. We established two data groups: one group of stream reaches (annual panel) that would be monitored annually, and a second larger group (pulsed panel) that would be monitored on a pulsed schedule (Table 8). All study reaches (existing and newly established in 2003-2004) were surveyed during a pulse period that was three to four years long (2003 to 2006). In 2007, we continued monitoring at the newly established study reaches but reduced the number of surveys at the old study reaches. The latter subset of reaches forms the annual panel. The pulsed strategy was implemented to minimize monitoring cost over time yet maintain our ability to detect trends (Bryant 1995). Annual monitoring was maintained at several reaches to document habitat changes that may occur in response to major storm events during the pulse intervals. We learned from our past studies (Martin and Shelly 2005) that knowledge of storm related impacts can help us to interpret how habitat responses relate to logging versus natural environmental processes.

During 2007 we learned that logging was implemented at some of the new study reaches, logging was delayed at some reaches, and two reaches are no longed proposed for timber harvest. When we established these sites in 2003/2004, all of the sites were expected to be conventionally logged and to have 66-ft buffers. Currently, we understand that three sites will be conventionally logged (one in-progress and two proposed for 2008-2009), four sites will be helicopter logged (two completed, one in-progress, and one proposed for 2008-2009), and two sites will probably never have logging anywhere near (i.e., within 300 to 400 ft) the riparian zone (Table 8). The sites with conventional logging will have standard buffer strips (i.e., minimum 66 ft wide) on one or both sides of the stream, and the sites that are logged by helicopter will have intact riparian stands with small clearcut patches (e.g., 3-10 trees removed) no closer than 66 ft from the stream. A variance may allow some harvest within the buffer strips at the conventional and helicopter units. The intensity of harvest at the helicopter sites is significantly smaller than a conventional clearcut and will probably have a smaller effect on riparian stands/ecological functions.

The shift in logging plans and the protracted harvest period (2007-2009) has changed the proposed sample population and caused us to adjust the future monitoring schedule. First, we propose that monitoring continue at the helicopter sites (i.e., Game 8, Fisheye, Trocadero S26, View Cove) and at the unlogged sites (i.e., Estrella and Gartina 1b) to provide a new group of unlogged or minimally impacted reference monitoring sites. These sites could be compared to the post-harvest and pre/post-harvest trend sites in an unpaired treatment versus reference analysis. The reference designation for the helicopter sites would depend on riparian stand conditions several years after logging. Helicopter sites with conditions that are similar to the unlogged sites (i.e., windthrow and LWD recruitment) would be considered reference sites, and those with more disturbance would be treated accordingly. Second, we propose that existing data from 2003-2007 monitoring at the new sites is sufficient to document pre-harvest conditions (i.e., 3-5 years of data) and that continued collection of pre-harvest data is probably not cost-effective. Third, post-harvest monitoring is recommended immediately following logging at the conventional harvest sites but may be delayed at the helicopter harvest sites because changes at the helicopter sites will probably be small and may occur slowly over time. Fourth, we propose to select monitoring sites for the annual surveys that represent a range of conditions (logged and unlogged, recent and old logging) and geographic locations (Hoonah and Craig).

Table 8. **Existing and proposed future trend monitoring schedule by analysis group, timber harvest period, and survey time. Highlighted cells in yellow or orange indicate monitoring during post-harvest period; highlighted cells in green indicate monitoring during pre-harvest period. Cells with an "X" indicate existing data.**

				Existing Monitoring Schedule														Proposed Schedule							
Area	**Stream**	**Ch. Type**	**Harvest Year**	**94**	**95**	**96**	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**
	Post-Harvest Data Group																								
Craig	Cabin 4b	FP	1992	X	X		X					X	X	X				annual		pulse				annual	
Craig	Cabin 5	FP	1992	X	X		X					X	X	X											
Hoonah	Eagle 1	MM	1993	X	X	X	X					X	X	X	X	X									
Hoonah	Eagle 3	MM	1993	X	X	X	X						X	X	X										
Hoonah	E. Eagle 1	FP	1993	X	X	X	X					X	X	X		X									
Hoonah	E. Eagle 2a	MM	1993	X	X	X	X					X	X	X											
Hoonah	Game 6a	FP	1992		X	X	X	X	X					X	X										
	Pre- and Post-Harvest Data Group																								
Craig	Caldera	MM	2000		X	X	X					X	X	X											
Craig	Coco 1a	MM	2002	X	X	X	X					X	X	X	X	X									
Craig	Coco 2a	MM	2003	X	X	X	X					X	X	X	X	X									
Hoonah	Game 3.	MM	2002		X	X	X	X	X				X	X	X										
Hoonah	Game 4a	MM	1998		X	X	X	X	X				X	X	X										
Craig	Raven	MM	1999			X	X					X	X	X											
	New Pre- and Post-Harvest Data Group																								
Hoonah	Game 8	MM	proposed 09				X							X	X	X	X								
Hoonah	Gartina 1b	MM	---									X	X	X	X	X									
Hoonah	Gartina 2	FP	proposed 08									X	X	X	X	X									
Craig	Estrella	FP	---		X	X	X						X	X	X	X	X								
Craig	Fish Eye	MM	2007										X	X	X	X									
Craig	Hetta	MM	proposed 09											X	X	X	X								
Craig	Trocadero S21	MM	2007-2008										X	X	X	X									
Craig	Trocadero S26	MM	2007-2008										X	X	X	X									
Craig	View Cove	MM	2007										X	X	X	X									

Unlogged | Conventional Logged | Helicopter Logged

Based on the guidelines listed above we propose that monitoring during 2008 and 2009 be continued at nine specific annual monitoring sites (Table 8) to provide a continuous record of inter-annual variability. To minimize cost of travel and to maximize data collection, we chose to survey four pairs of survey sites where each pair could be accessed and surveyed in a single day. We also propose to continue monitoring at Estrella, a long-term un-harvested control site.

We recommend that the pulsed monitoring schedule (survey of all 22 sites) resume after timber harvest is completed at all new monitoring sites (i.e., 2010; Table 8). This would facilitate an initial evaluation of harvest effects at the new sites and would enable an examination of trends at all of the old monitoring sites. The pulsed monitoring should continue for two to three years (2010-2012) to capture and document the trends in habitat conditions. The need for future monitoring beyond 2012 would be evaluated at that time.

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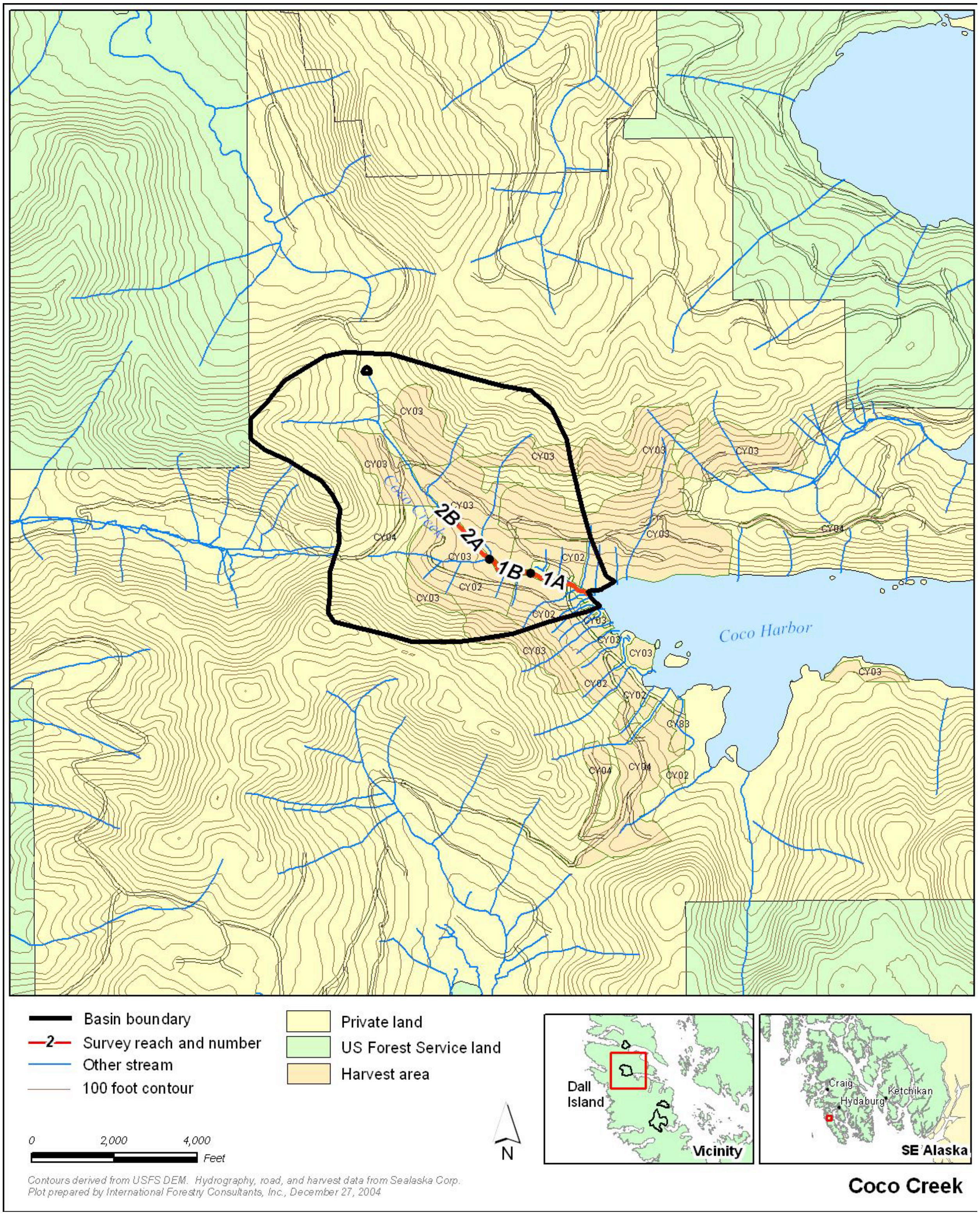
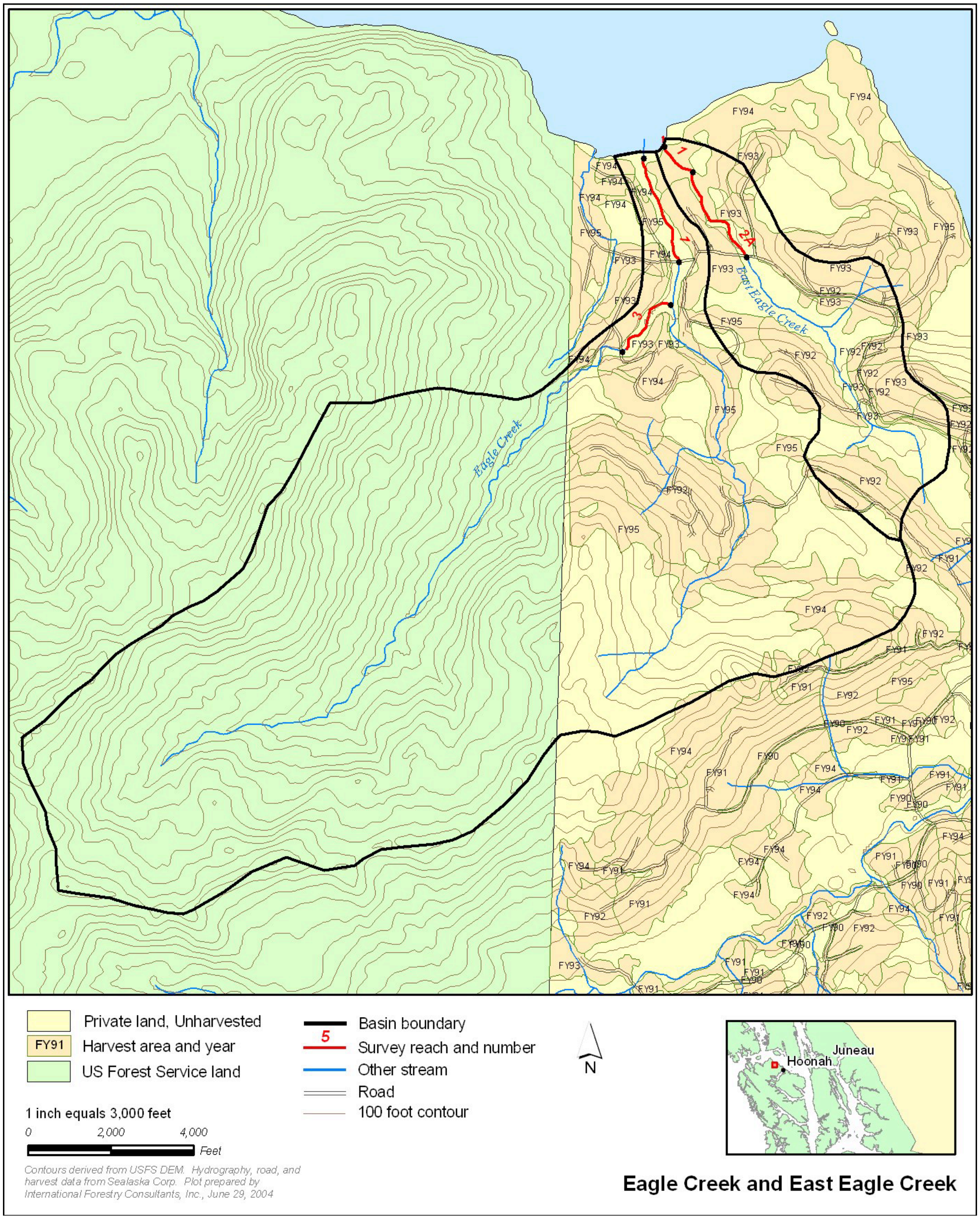
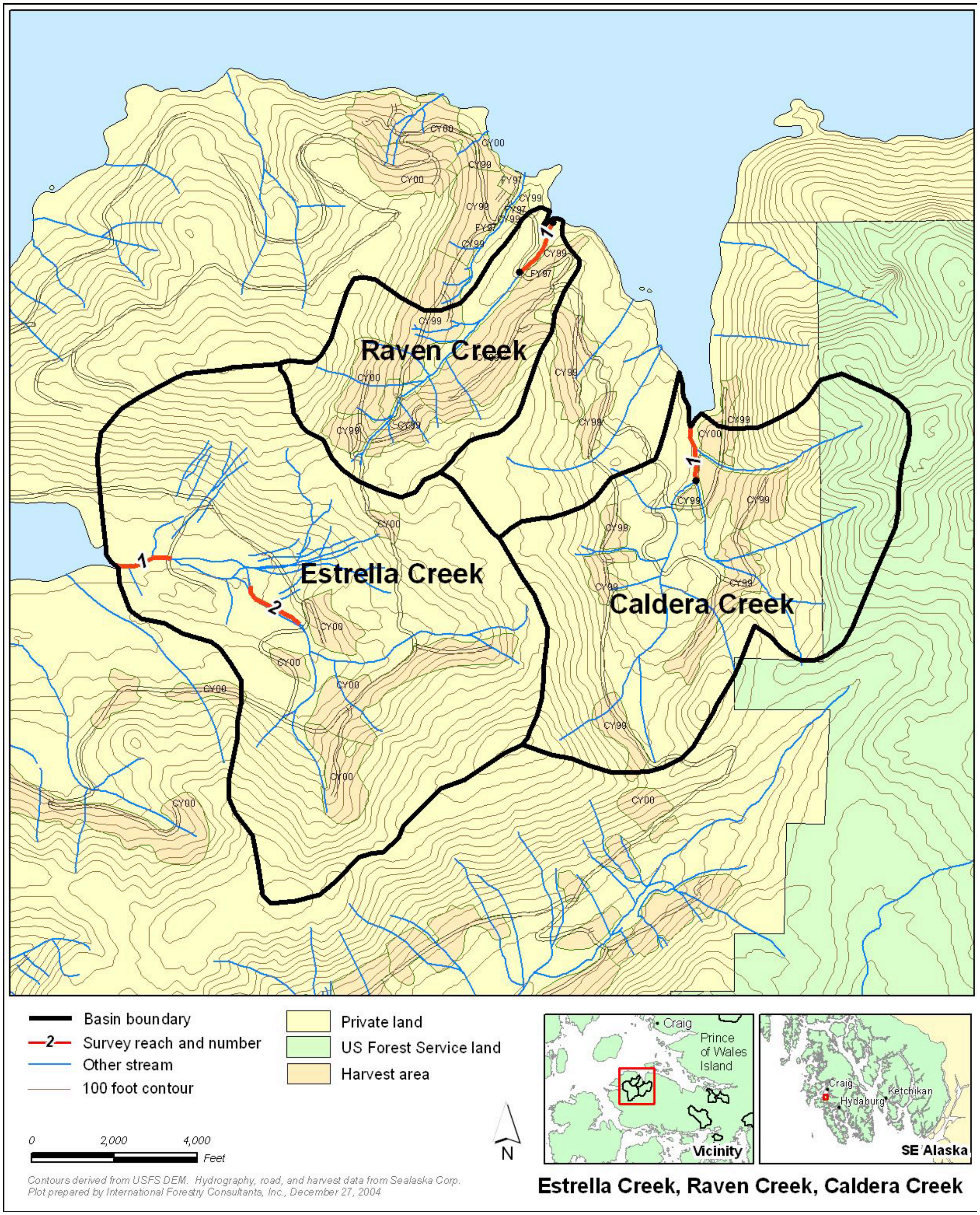
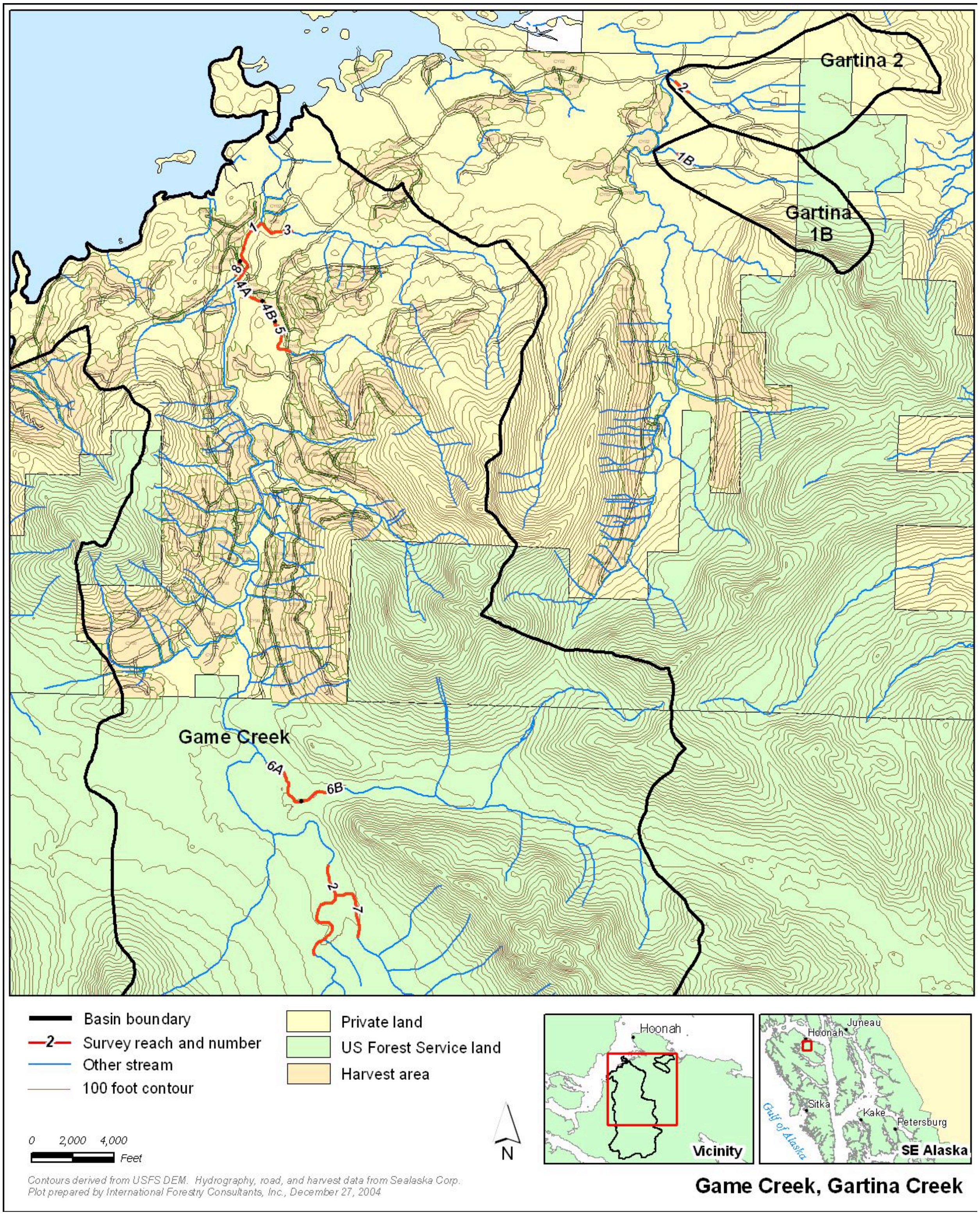
Appendix A—Basin Maps

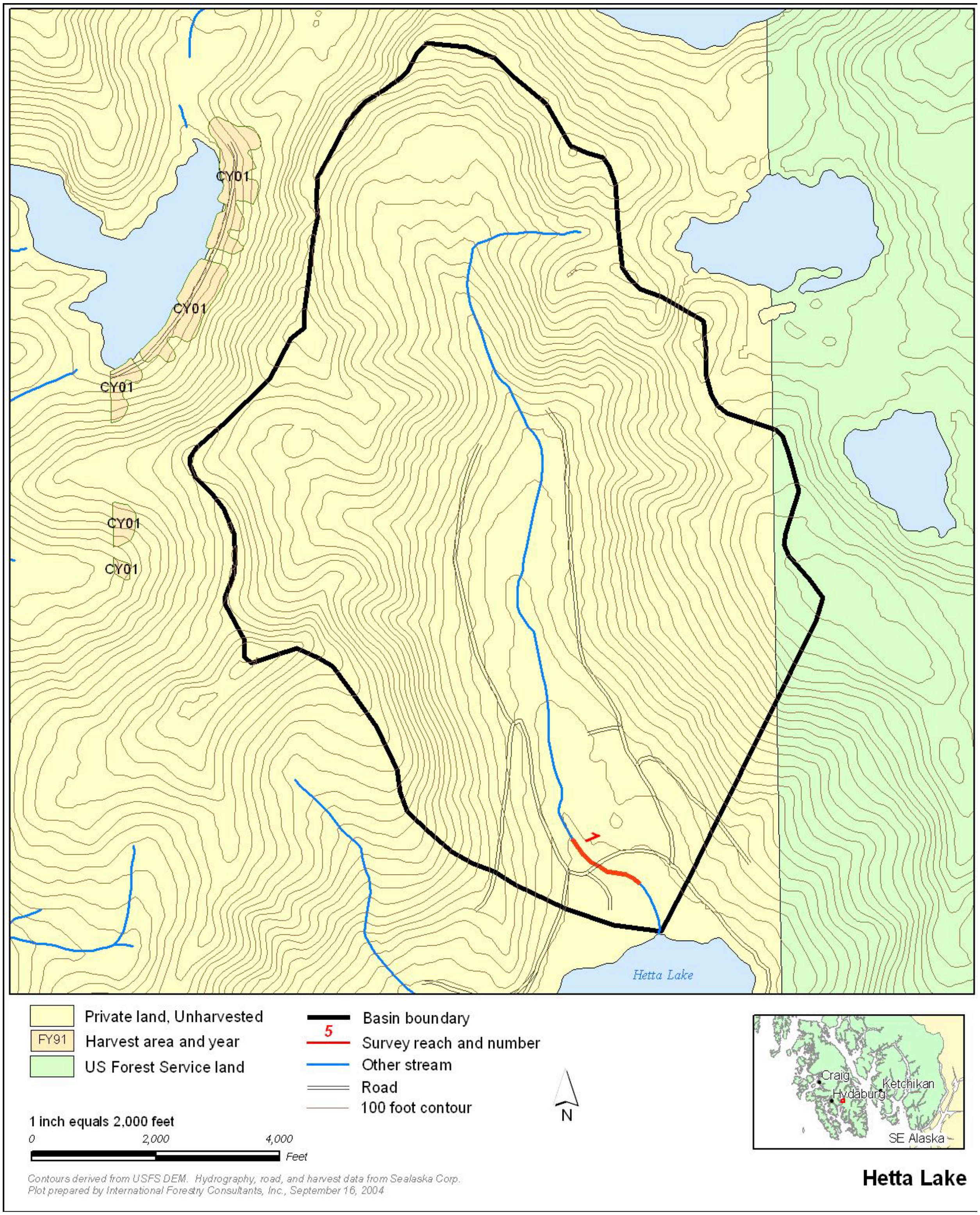


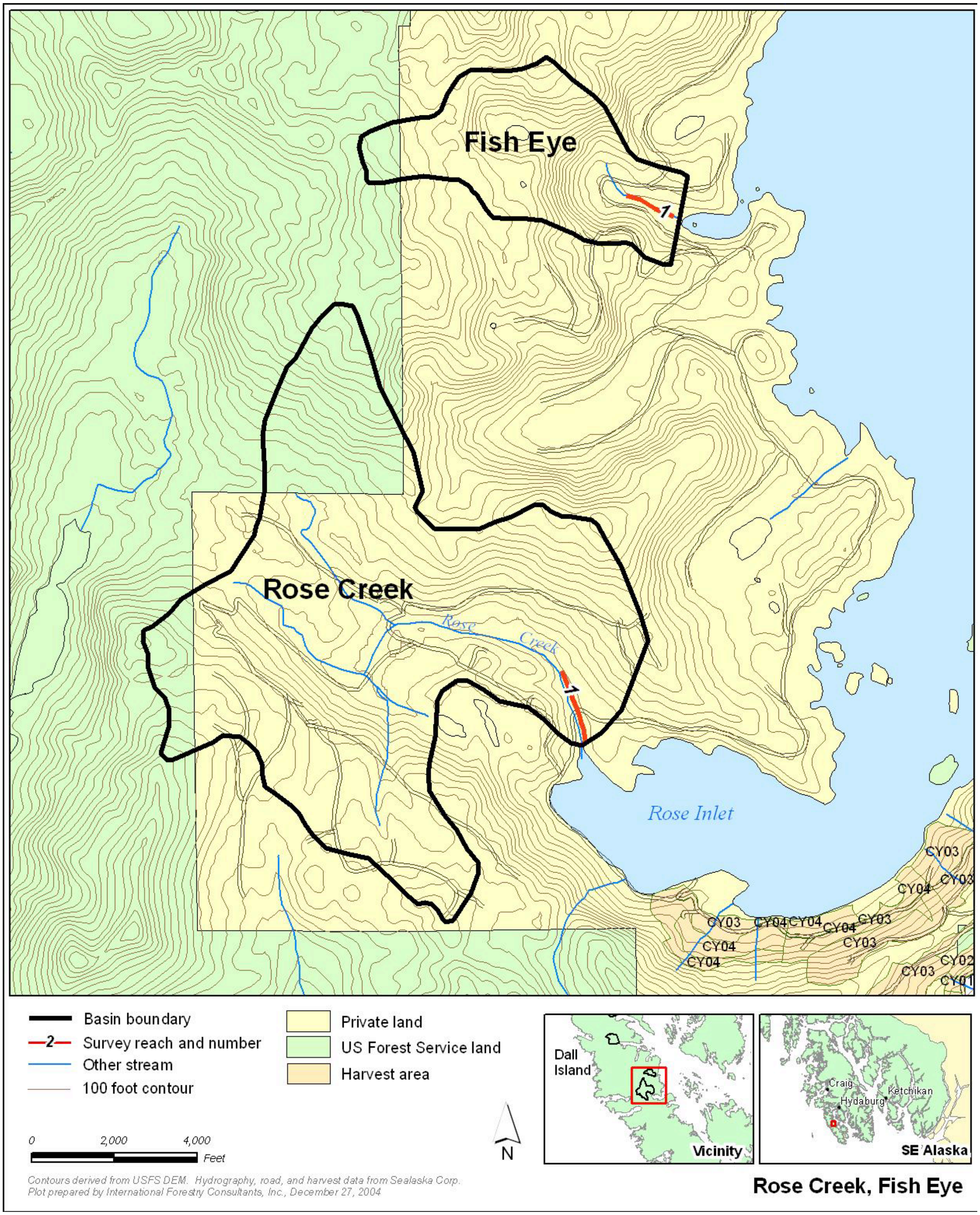
Coco Creek
Coco Harbor
2B
2A
1B
1A
CY02
CY03
CY04
Basin boundary
2 Survey reach and number
Other stream
100 foot contour
Private land
US Forest Service land
Harvest area
0
2,000
4,000
Feet
N
Dall Island
Vicinity
Craig
Ketchikan
Hydaburg
SE Alaska
Contours derived from USFS DEM. Hydrography, road, and harvest data from Sealaska Corp.
Plot prepared by International Forestry Consultants, Inc., December 27, 2004
Coco Creek


Eagle Creek
East Eagle Creek
Private land, Unharvested
FY91 Harvest area and year
US Forest Service land
Basin boundary
5 Survey reach and number
Other stream
Road
100 foot contour
1 inch equals 3,000 feet
0 2,000 4,000
Feet
N
Juneau
Hoonah
Contours derived from USFS DEM. Hydrography, road, and harvest data from Sealaska Corp. Plot prepared by International Forestry Consultants, Inc., June 29, 2004
Eagle Creek and East Eagle Creek

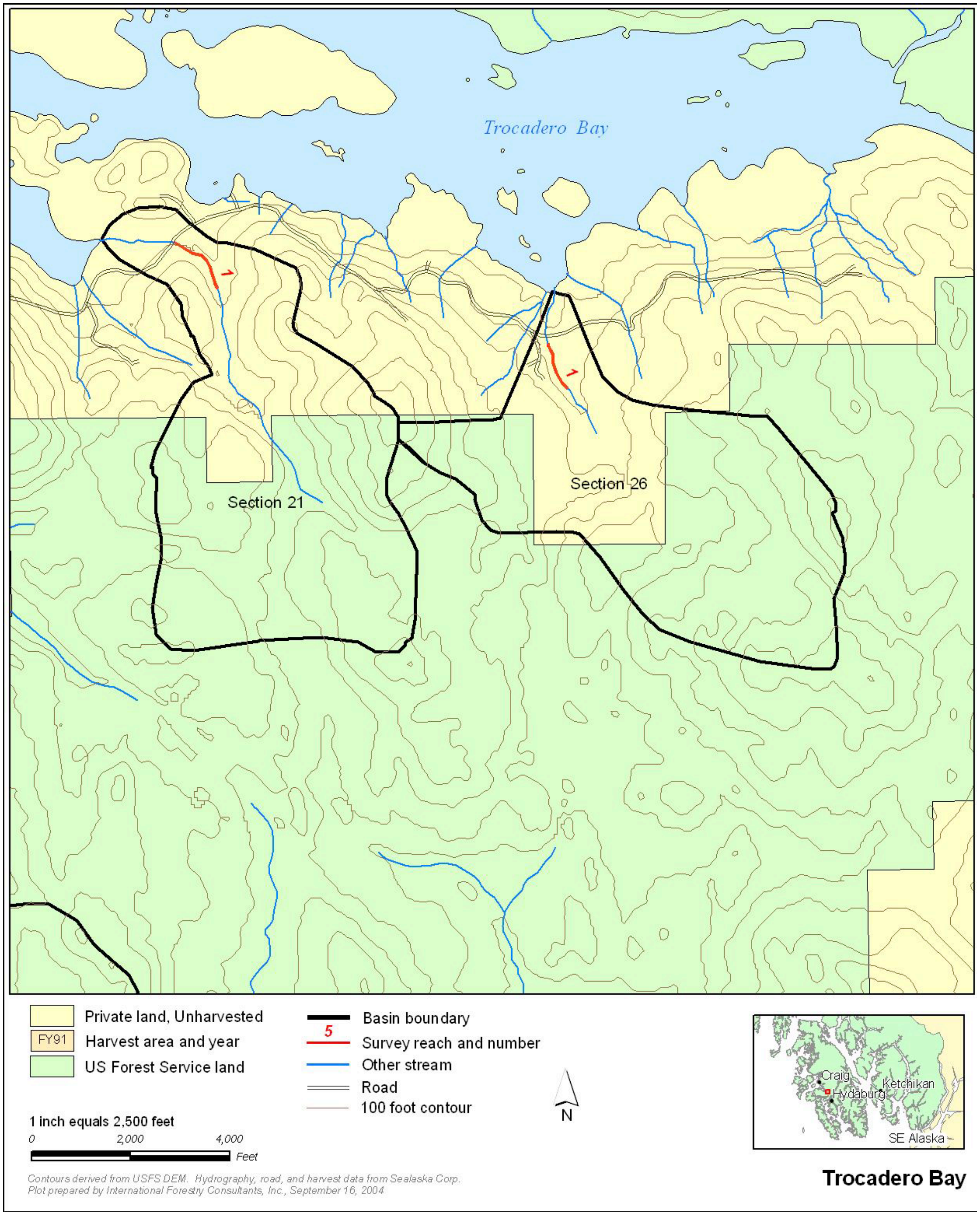

Raven Creek
Estrella Creek
Caldera Creek
Basin boundary
Survey reach and number
Other stream
100 foot contour
Private land
US Forest Service land
Harvest area
0
2,000
4,000
Feet
N
Craig
Prince of Wales Island
Vicinity
Hydaburg
Ketchikan
SE Alaska
Contours derived from USFS DEM. Hydrography, road, and harvest data from Sealaska Corp.
Plot prepared by International Forestry Consultants, Inc., December 27, 2004
Estrella Creek, Raven Creek, Caldera Creek

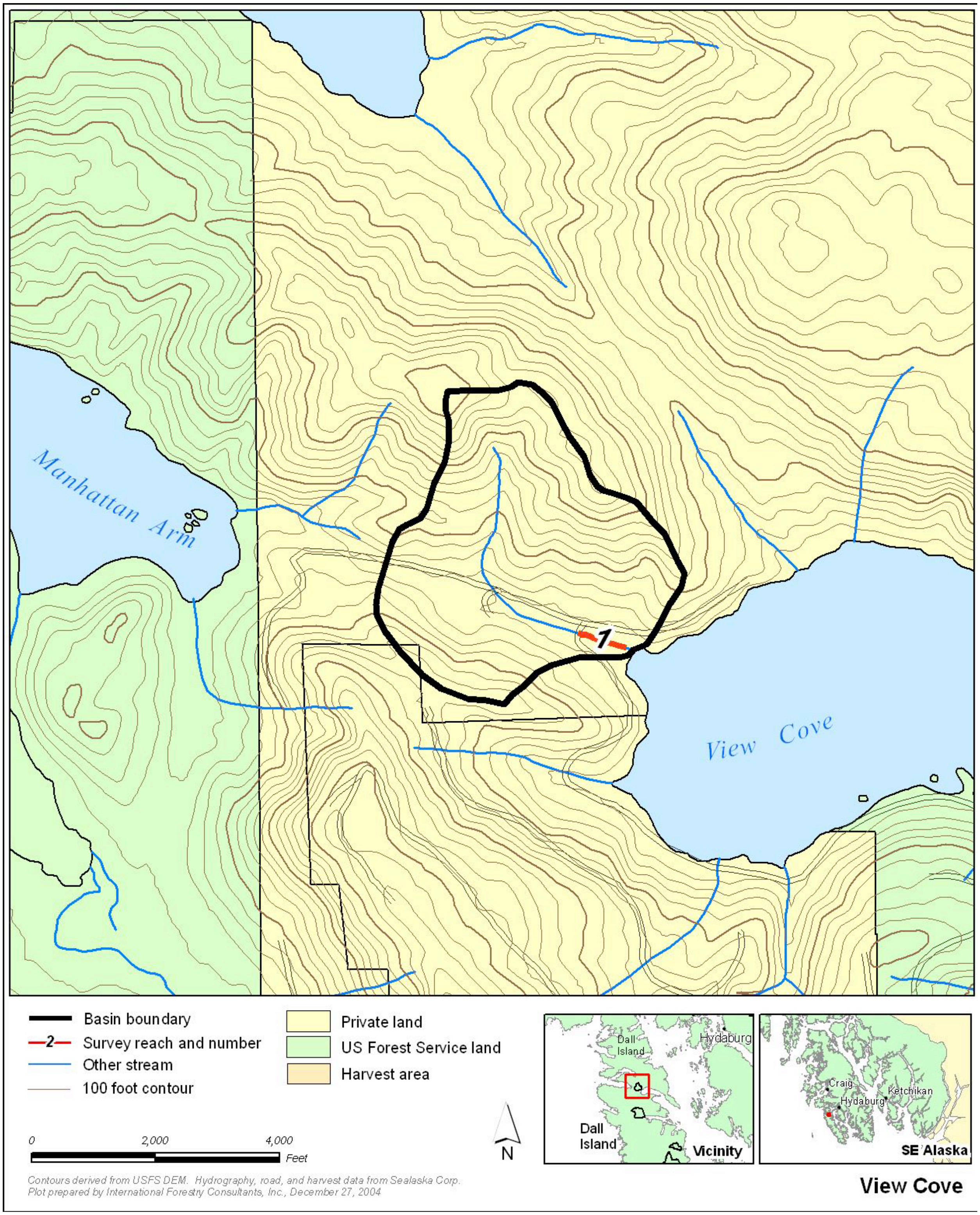

Gartina 2
2
1B
Gartina
1B
1
3
8
4A
4B
5
Game Creek
6A
6B
2
7
Basin boundary
Survey reach and number
Other stream
100 foot contour
Private land
US Forest Service land
Harvest area
0 2,000 4,000
Feet
N
Hoonah
Vicinity
Juneau
Hoonah
Sitka
Kake
Petersburg
Gulf of Alaska
SE Alaska
Contours derived from USFS DEM. Hydrography, road, and harvest data from Sealaska Corp.
Plot prepared by International Forestry Consultants, Inc., December 27, 2004
Game Creek, Gartina Creek


CY01
CY01
CY01
CY01
CY01
1
Hetta Lake
Private land, Unharvested
FY91 Harvest area and year
US Forest Service land
Basin boundary
5 Survey reach and number
Other stream
Road
100 foot contour
N
Craig
Ketchikan
Hydaburg
SE Alaska
1 inch equals 2,000 feet
0 2,000 4,000
Feet
Contours derived from USFS DEM. Hydrography, road, and harvest data from Sealaska Corp.
Plot prepared by International Forestry Consultants, Inc., September 16, 2004
Hetta Lake



Fish Eye
1
Rose Creek
Rose
Creek
1
Rose Inlet
CY03
CY04
CY02
CY01
Basin boundary
2 Survey reach and number
Other stream
100 foot contour
Private land
US Forest Service land
Harvest area
0
2,000
4,000
Feet
N
Dall Island
Vicinity
Craig
Hydaburg
Ketchikan
SE Alaska
Contours derived from USFS DEM. Hydrography, road, and harvest data from Sealaska Corp.
Plot prepared by International Forestry Consultants, Inc., December 27, 2004
Rose Creek, Fish Eye


Trocadero Bay
Section 21
Section 26
Private land, Unharvested
FY91
Harvest area and year
US Forest Service land
Basin boundary
5
Survey reach and number
Other stream
Road
100 foot contour
N
1 inch equals 2,500 feet
0
2,000
4,000
Feet
Craig
Hydaburg
Ketchikan
SE Alaska
Contours derived from USFS DEM. Hydrography, road, and harvest data from Sealaska Corp.
Plot prepared by International Forestry Consultants, Inc., September 16, 2004
Trocadero Bay


Manhattan Arm
View Cove
1
Basin boundary
2 Survey reach and number
Other stream
100 foot contour
Private land
US Forest Service land
Harvest area
0
2,000
4,000
Feet
N
Dall Island
Hydaburg
Dall Island
Vicinity
Craig
Hydaburg
Ketchikan
SE Alaska
Contours derived from USFS DEM. Hydrography, road, and harvest data from Sealaska Corp.
Plot prepared by International Forestry Consultants, Inc., December 27, 2004
View Cove

Appendix B—Trend Analysis Results

Appendix Table B-1. Results of trend analyses for selected habitat metrics at the new monitoring reaches. Includes data for period 2003 to 2007 for all sites.

Stream reach	Slope of trend lines						
	RPL (%)	Mean res. depth (cm)	Median res. depth (cm)	Pool freq. (no./100 m)	green recruits (no./100 m)	twig-branch recruits (no./100 m)	In-stream LWD (no./100 m)
Estrella 1	-1.05	-0.86	-0.60	0.21	-0.02	0.30	5.78
Fisheye 1	0.45	1.84	3.50	0.17	0.14	-0.50	-1.60
Game 8	-0.61	-1.01	-1.00	0.37	0.001	0.09	-2.12
Gartina 1b	1.93	0.62	0.30	0.20	0.07	-0.24	3.02
Gartina 2	-0.24	1.09	-0.20	0.72	0.00	-0.31	-0.57
Hetta 1	0.68	-1.40	0.85	0.61	-0.53	-0.13	1.00
Trocadero Sec 21	-1.39	-0.90	-1.80	-0.32	2.59	-0.03	2.21
Trocadero Sec 26	-4.98	-0.84	0.25	-0.54	1.16	-0.15	6.74
View Cove 1	3.12	-0.70	-0.60	0.56	0.03	-0.45	6.34
Mean Slope	-0.23	-0.24	0.08	0.22	0.38	-0.16	2.31
Standard Error	0.81	0.40	0.53	0.15	0.33	0.09	1.21
Without all-zero data:							
Mean Slope	---	---	---	---	0.43	---	---
Standard Error	---	---	---	---	0.37	---	---
two-tailed t-test p-value	0.769	---	0.880	0.156	---	0.102	0.077
Wilcoxon p-value (for non-normal)	---	0.570	---	---	0.172	---	---
Without all-zero data (Wilcoxon)	---	---	---	---	0.195	---	---

Appendix Table B-2. Results of trend analyses for selected habitat metrics at the new monitoring reaches. Includes data for period 2003 to 2007 for all sites except 2007 data from recently logged sties (Fish Eye, Trocadero Sec 21, View Cove) is excluded.

	Slope of trend lines						
Stream reach	RPL (%)	Mean res. depth (cm)	Median res. depth (cm)	Pool freq. (no./100 m)	green recruits (no./100 m)	twig-branch recruits (no./100 m)	In-stream LWD (no./100 m)
Estrella 1	-1.05	-0.86	-0.60	0.21	-0.02	0.30	5.78
Fisheye 1	-0.14	1.88	3.50	0.23	0.00	-0.63	-4.85
Game 8	-0.61	-1.01	-1.00	0.37	0.001	0.09	-2.12
Gartina 1b	1.93	0.62	0.30	0.20	0.07	-0.24	3.02
Gartina 2	-0.24	1.09	-0.20	0.72	0.00	-0.31	-0.57
Hetta 1	0.68	-1.40	0.85	0.61	-0.53	-0.13	1.00
Trocadero Sec 21	1.98	-0.68	-1.00	-0.05	-0.58	0.26	-6.83
Trocadero Sec 26	-1.32	-5.45	-4.50	0.75	-0.38	-0.38	-2.08
View Cove 1	3.29	-1.07	-0.50	0.44	0.16	-0.05	-2.88
Mean Slope	0.50	-0.76	-0.35	0.39	-0.14	-0.12	-1.06
Standard Error	0.56	0.74	0.74	0.10	0.10	0.11	1.37
Without all-zero data:							
Mean Slope	---	---	---	---	-0.18	---	---
Standard Error	---	---	---	---	0.12	---	---
two-tailed t-test p-value	0.368	0.305	0.629	0.003	---	0.268	0.438
Wilcoxon p-value (for non-normal)	---	---	---	---	0.437	---	---
Without all-zero data (Wilcoxon)	---	---	---	---	0.375	---	---

Appendix Table B-3. Results of trend analyses for substrate size composition.

All data			Excludes 2007 recently logged data		
	Slope of trend lines			Slope of trend lines	
Stream reach	**d_{16}**	**d_{50}**	**Stream reach**	**d_{16}**	**d_{50}**
Estrella 1.0	-0.158	-1.749	Estrella 1.0	-0.158	-1.749
Estrella 1.128	-1.133	-2.030	Estrella 1.128	-1.133	-2.030
Estrella 1.300	-1.875	-2.590	Estrella 1.300	-1.875	-2.590
Fisheye 1.3	0.694	-0.087	Fisheye 1.3	-0.798	-3.133
Fisheye 1.245	-2.713	-1.389	Fisheye 1.245	-1.042	2.453
Fisheye 1.320	-1.835	-3.162	Fisheye 1.320	-1.812	-3.660
Game 8.73	0.681	0.491	Game 8.73	0.681	0.491
Game 8.128	-2.999	-1.395	Game 8.128	-2.999	-1.395
Game 8.202	-1.081	-1.757	Game 8.202	-1.081	-1.757
Gartina 1b.377	3.088	5.665	Gartina 1b.377	3.088	5.665
Gartina 1b.483	-0.198	2.092	Gartina 1b.483	-0.198	2.092
Gartina 1b.585	0.158	3.576	Gartina 1b.585	0.158	3.576
Gartina 2.130	-1.184	-2.890	Gartina 2.130	-1.184	-2.890
Gartina 2.205	-0.836	-1.667	Gartina 2.205	-0.836	-1.667
Gartina 2.290	-0.046	-1.099	Gartina 2.290	-0.046	-1.099
Hetta 1.76	-2.526	-2.501	Hetta 1.76	-2.526	-2.501
Hetta 1.168	-0.041	0.106	Hetta 1.168	-0.041	0.106
Hetta 1.275	-0.827	-2.525	Hetta 1.275	-0.827	-2.525
Trocadaro Sec 21.0	-4.020	-7.181	Trocadaro Sec 21.0	-4.172	-6.706
Trocadaro Sec 21.135	-2.638	-3.578	Trocadaro Sec 21.135	-2.218	-0.372
Trocadaro Sec 21.316	-3.513	-6.423	Trocadaro Sec 21.316	-2.378	-5.932
Trocadaro Sec 26.0	-2.158	-5.502	Trocadaro Sec 26.0	-3.526	-4.954
Trocadaro Sec 26.105	-6.724	-11.211	Trocadaro Sec 26.105	-7.533	-11.129
Trocadaro Sec 26.255	-0.860	-3.836	Trocadaro Sec 26.255	0.767	-0.266
View Cove 1.57	-1.459	-2.361	View Cove 1.57	-1.638	-2.303
View Cove 1.355	-2.487	-2.800	View Cove 1.355	-3.166	-4.854
Mean Slope	-1.411	-2.146		-1.404	-1.890
Standard Error	0.375	0.664		0.397	0.678
two-tailed t-test p-value	0.000757	0.0029201		0.00135	0.0088081