Status and Trends of Fish Habitat Condition on Private Timberlands in Southeast Alaska: 2008 Summary

Douglas Martin

Martin Environmental

Status and Trends of Fish Habitat Condition on Private Timberlands in Southeast Alaska: 2008 Summary

Final Report

(Alaska Clean Water Action Grant No: 09-11)

Prepared for:

Sealaska Corporation

and

Alaska Department of Environmental Conservation

Prepared by:

Douglas J. Martin
Martin Environmental
2103 N 62nd Street
Seattle, Washington 98103

March 25, 2009

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

The Sealaska Corporation, the Alaska Department of Environmental Conservation, and the Alaska Department of Natural Resources funded this research as a cooperative effort under the Alaska Clean Water Action Program (ACWA Grant No: 09-11). We thank Ron Wolf, Nathan Soboleff, and John Hillman (Sealaska Corporation) for contract management and overall project support. Special thanks to the project field crew: Bernard Romey, Eli Martin, and Lauren Austin for their enthusiastic assistance in gathering field data and Lew White (Sealaska) for bear guard service. Tim Merriman (Port Frederick Lodge) provided boat charter services in Hoonah, and Scott Ownbey (Shinaku Charters) provided boat charter services in Craig. Thanks to Ted Hitzroth (International Forestry Consultants, Inc.) for map production and GIS services.

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 2008, 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 2008 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 2008 field season and presents selected results from 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 (Martin 1994, 1995, 1996; Martin et al. 1996, 1997, 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, 2008). 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 (see Martin and Shelly 2006). We established two monitoring 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. In 2006 we shifted monitoring to the annual panel (small group) and continued this schedule through 2008.

In 2008 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 2008 findings in a data report.

This report summarizes the data that were collected during the 2008 field season and presents selected results from the new monitoring reaches.

2.0 STUDY AREA

In 2008 we collected data at 10 study sites that include 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 three basins in the Craig area (Figure 1). Most of the reaches in both areas were MM channel type (Table 1). Seven study reaches had buffer zones with timber harvest on one or both sides of the stream as of July 2008. Buffer strip widths and lengths vary among the study reaches. Buffer strips bordered the entire lengths of the older reaches (i.e., Eagle 1, East Eagle 1, Coco 1a, 2a). At the Trocadero and Gartina 2 sites (new study reaches), the buffer strips were generally greater than 20 m wide and only occurred along portions of the survey reaches. There are no harvest plans for the other study reaches (Game 8, Gartina 1b, Estrella) at this time (see Section 5.0 Future Monitoring).

Table 1. Physical characteristics, timber harvest period, and survey history at 2008 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	10
East Eagle 1	327	6.3	FP	2 sides	1992-93	1994	9
Game 8	215	4.9	MM	unlogged	none	1997	6
Gartina 1b	294	4.9	MM	unlogged	none	2003	6
Gartina 2	281	6.6	FP	1 side	2008	2003	6
Craig Area							
Coco 1a	436	8.8	MM	2 sides	2002	1994	10
Coco 2a	330	6.2	MM	2 sides	2003	1994	10
Estrella 1	522	14.1	FP	unlogged	none	1995	9
Trocadero Sec 21	347	7.8	MM	2 sides	2007-08	2004	5
Trocadero Sec 26	260	8.6	MM	2 sides	2007-08	2004	5

[a] From Paustian et al. (1992)

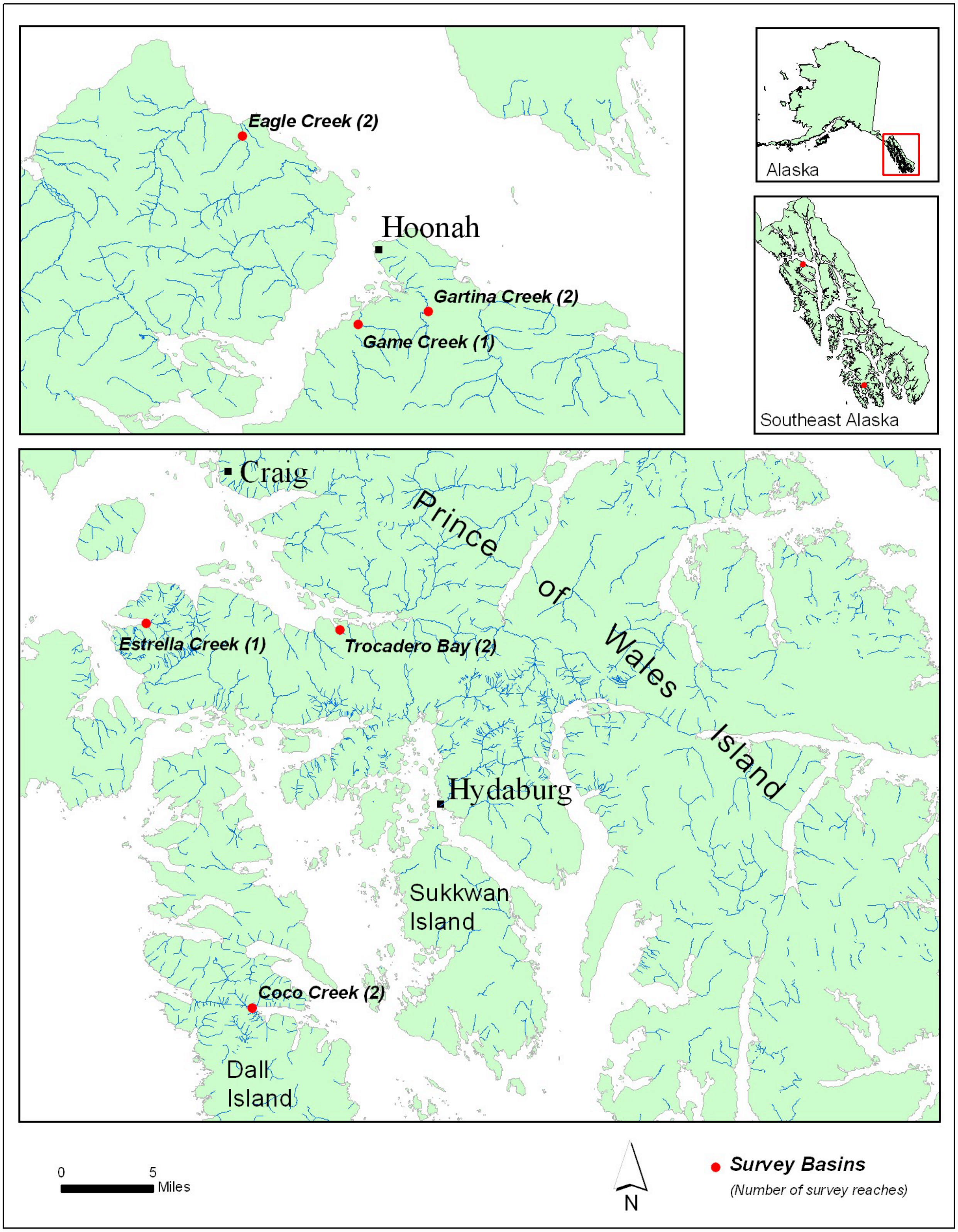


Figure 1. Location of stream basins that were surveyed during 2008. Number in parentheses denotes the number of stream reaches that were surveyed at each basin.

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 with a graduated rod at one location for fast water units and at two locations for pools. 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 2008 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) and substrate size composition measurements were taken at three to seven 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 ANALYSIS

We plotted the data for key habitat variables at the new monitoring reaches for the 2003 to 2008 period. These plots include trend lines that show annual direction or changes in the variables over time. No statistical analyses were performed at this time.

4.0 SUMMARY OF 2008 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.

The recruitment of new LWD (i.e., green recruits) was observed at six of the ten monitoring reaches (Table 3). New recruitment occurred at both logged and unlogged reaches, and the highest rate occurred at Trocadero Sec 21, which was recently logged (2007). Recruitment rates have increased greatly at both Trocadero reaches in the past two years since logging and have remained relatively low at the other study reaches (Figure 2).

LWD loading densities and volume were highly variable among the study reaches (Table 4). The unlogged reaches had the lowest and highest loadings (i.e., Gartina 1b and Estrella 1) with the exception of Trocadero Sec 26, which had the highest LWD density. LWD densities have greatly increased at both Trocadero reaches in the past two years since logging (Figure 3). Densities have also increased at Estrella during the same time period even though no logging has occurred in this area.

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 second 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 2.0 to 8.0 pools/100 m, and RPA ranged from 14% to 69% (Table 6). Pool frequency appears to be increasing at several logged and unlogged stream reaches (Game 8, Gartina 2, Hetta 1, View Cove) and declining at both Trocadero reaches (Figure 4). The trends in RPL are less dramatic at most reaches except for Trocadero Sec 26, which shows a strong declining pattern. Trends in residual pool depth are relatively stable at all reaches except Fisheye, where depths are increasing over time (Figure 5).

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. Trends in substrate d_{50} were relatively flat or slightly declining at all but two study reaches (Figure 6). At Gartina 1b the d_{50} is increasing at two of the three sample sites, and at Trocadero Sec 26 the d_{50} is increasing at one of three sample sites.

Table 3. Number of LWD recruits, recruit rate, and percentage of recruits by decay class for each stream reach during 2008.

Stream reach	Recruits (no.) Above channel	In channel	Total	In channel density (no/100 m)	Decay class (%) Green	Twig	Branch	Primary	Nubs	Old	Total green density (no./100 m/yr.)
Coco 1a	18	37	55	8.4	7.3	29.1	21.8	1.8	10.9	29.1	0.90
Coco 2a	42	26	68	7.3	1.5	17.6	61.8	5.9	5.9	7.4	0.28
Eagle 1	32	42	74	4.6	1.4	14.9	18.9	20.3	20.3	24.3	0.11
E Eagle 1	28	35	63	10.6	0.0	38.1	14.3	12.7	25.4	9.5	0.00
Estrella 1	24	61	85	11.5	2.4	14.1	11.8	2.4	16.5	52.9	0.38
Game 8	10	21	31	9.8	6.5	3.2	9.7	22.6	38.7	19.4	0.93
Gartina 2	5	15	20	5.5	0.0	0.0	0.0	20.0	30.0	50.0	0.00
Gartina 1b	8	8	16	2.8	0.0	0.0	6.3	6.3	50.0	37.5	0.00
Trocadero Sec 21	41	41	82	11.5	7.3	40.2	6.1	4.9	12.2	29.3	1.69
Trocadero Sec 26	10	45	55	17.6	0.0	30.9	1.8	5.5	29.1	32.7	0.00

Table 4. LWD loading (number and volume) by stream reach during 2008.

Stream reach	LWD Pieces (no.)					LWD Volume (m^3)				
	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	18	229	247	51.8	92.7	27.9	283.0	310.9	64.0	91.0
Coco 2a	42	184	226	51.8	81.4	88.2	135.2	223.3	38.1	60.5
Eagle 1	32	583	615	63.4	94.8	82.6	304.5	387.1	33.1	78.7
E Eagle 1	28	148	176	44.7	84.1	30.7	67.8	98.5	20.5	68.8
Estrella 1	24	425	449	80.0	94.7	28.2	393.4	421.6	74.1	93.3
Game 8	11	90	101	42.1	89.1	11.5	44.0	55.6	20.6	79.2
Gartina 2	5	131	136	47.8	96.3	7.8	88.6	96.4	32.3	91.9
Gartina 1b	9	67	76	23.2	88.2	11.4	51.3	62.7	17.8	81.8
Trocadero Sec21	41	186	227	52.4	81.9	46.4	179.5	225.9	50.6	79.5
Trocadero Sec26	10	213	223	83.5	95.5	9.2	152.7	161.9	59.9	94.3

Table 5. Number of LWD jams and jam frequency by stream reach during 2008.

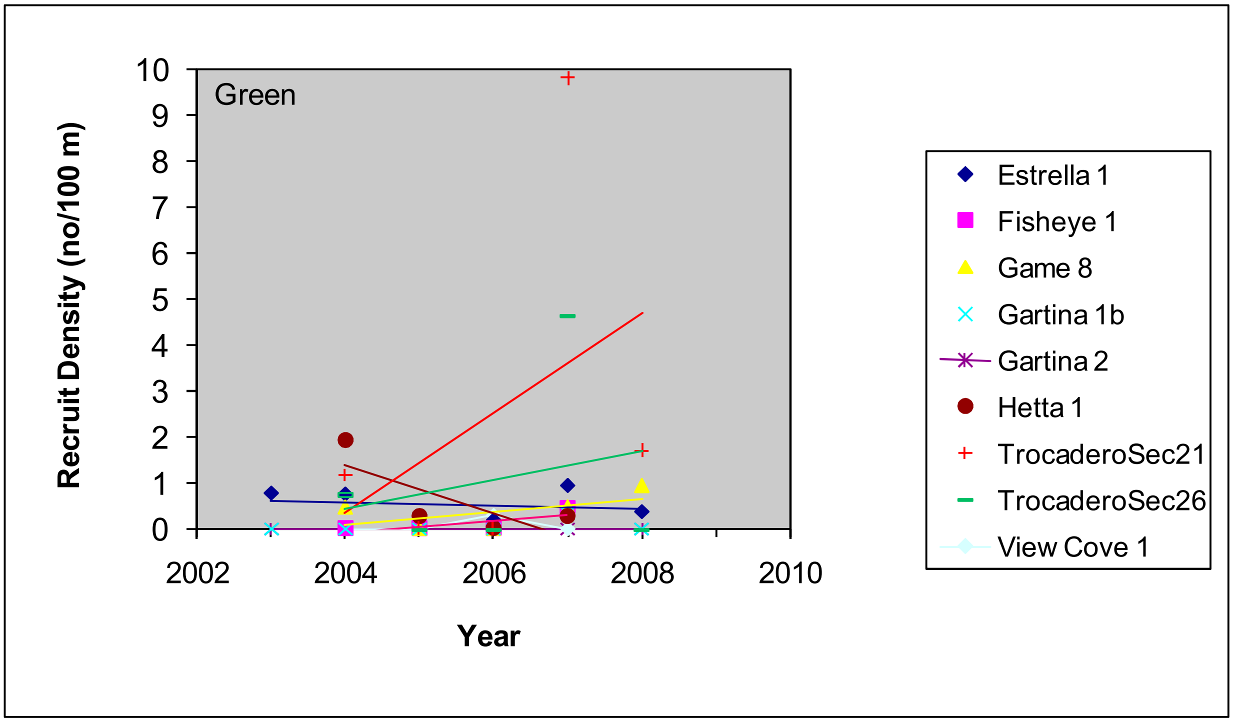
Stream reach	Number of jams	Jam frequency (no./100 m)
Coco 1a	13	2.9
Coco 2a	12	3.4
Eagle 1	10	1.1
E Eagle 1	8	0.9
Estrella 1	15	2.8
Game 8	12	5.6
Gartina 2	10	3.6
Gartina 1b	4	1.4
Trocadero Sec 21	13	3.7
Trocadero Sec 26	12	4.7

Table 6. Pool statistics for all primary pools within the main channel by stream reach during 2008.

Stream reach	Number	Pool frequency (no/100 m)	Pool spacing (cw/pool)	RPA (%)	RPL (%)	Residual depth (cm)		
						Mean	Median	Maximum
Coco 1a	20	4.5	2.7	43.4	36.7	51.2	41	117
Coco 2a	13	3.7	5.7	19.6	20.3	38.0	33	72
Eagle 1	18	2.0	4.2	13.8	15.3	44.3	40	78
East Eagle 1	19	5.7	2.9	48.4	43.8	43.7	34	77
Estrella 1a	27	5.1	1.4	47.6	42.9	59.7	59	86
Game 8	13	6.1	3.4	23.3	22.9	35.1	32	78
Gartina 1b	10	3.5	6.6	30.2	26.0	36.3	34.5	62
Gartina 2	22	8.0	1.9	68.8	58.8	45.4	42.5	80
Trocadero Sec 21	11	3.1	4.0	26.6	18.6	38.3	35	73
Trocadero Sec 26	8	3.1	4.3	23.7	21.2	45.6	39.5	92

Table 7. Substrate particle size (mm) by location and stream reach during 2008.

Stream reach	Cross section no.	D_{16}	D_{50}	D_{84}
Coco 1a	47	16.0	36.2	78.0
Coco 1a	160	19.9	45.3	98.0
Coco 1a	305	12.0	42.6	109.8
Coco 2a	887	12.0	39.1	93.4
Coco 2a	950	19.7	53.5	105.3
Coco 2a	1060	35.6	80.2	159.3
Coco 2a	1150	windthrow inhibited survey		
Coco 2a	1220	33.3	73.5	203.1
Eagle 1	0	3.3	26.1	80.6
Eagle 1	170	13.5	50.2	116.6
Eagle 1	305	18.2	42.0	97.4
Eagle 1	474	15.6	45.3	104.5
Eagle 1	570	11.8	28.4	88.8
Eagle 1	715	11.8	50.5	134.4
Eagle 1	865	19.0	56.7	147.0
East Eagle 1	35	4.7	12.5	29.1
East Eagle 1	160	4.9	17.0	46.5
East Eagle 1	275	5.5	16.2	39.6
Estrella 1a	0	8.0	20.8	43.5
Estrella 1a	128	6.7	17.9	30.7
Estrella 1a	300	8.3	22.9	60.1
Estrella 1b	573	6.1	21.0	44.5
Game 8	73	5.6	22.4	48.9
Game 8	128	6.5	19.2	56.6
Game 8	202	5.6	19.5	57.4
Gartina 1b	377	8.0	33.5	78.8
Gartina 1b	483	6.5	22.4	71.9
Gartina 1b	585	17.9	51.6	230.4
Gartina 2	130	5.3	16.6	39.9
Gartina 2	205	8.1	21.0	47.5
Gartina 2	290	6.1	18.2	44.4
Trocadero Sec 21	0	5.1	20.4	47.6
Trocadero Sec 21	135	7.3	40.7	102.4
Trocadero Sec 21	316	6.4	27.8	95.4
Trocadero Sec 26	0	11.9	41.3	121.3
Trocadero Sec 26	105	10.5	43.2	140.0
Trocadero Sec 26	255	19.4	49.1	115.5



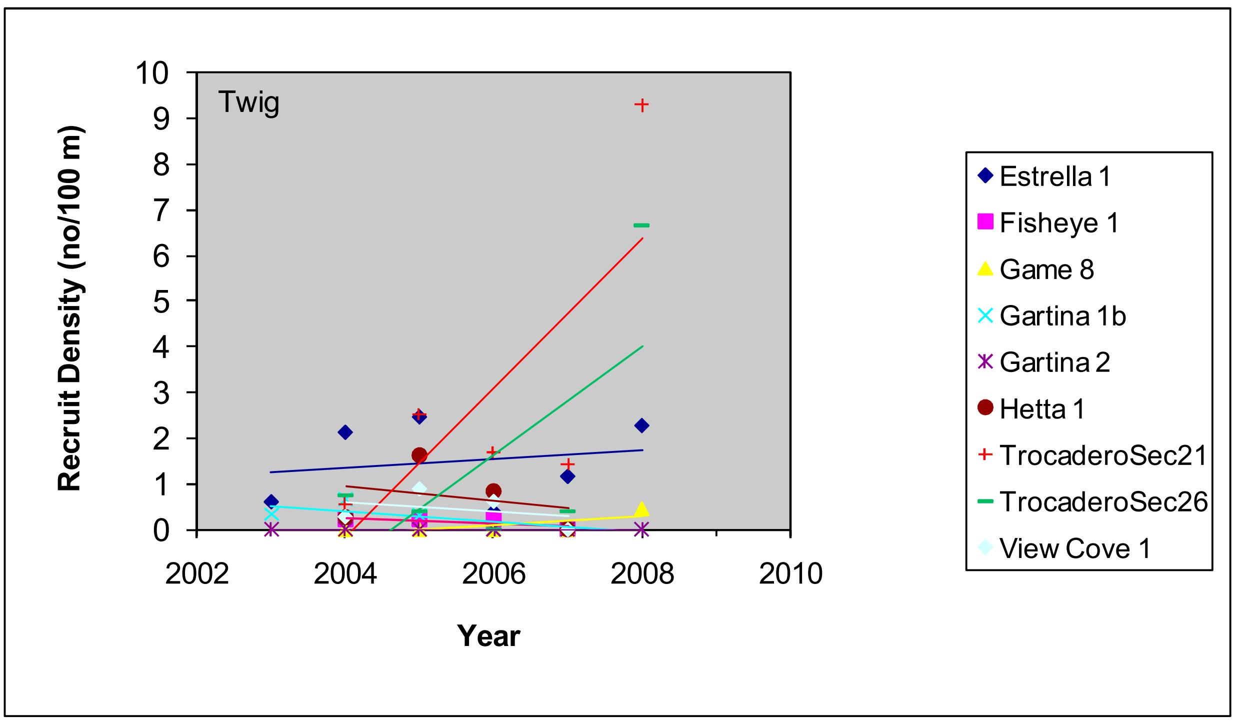


Figure 2. Trends in LWD recruit density for green and twig-branch decay classes at the new monitoring sites.

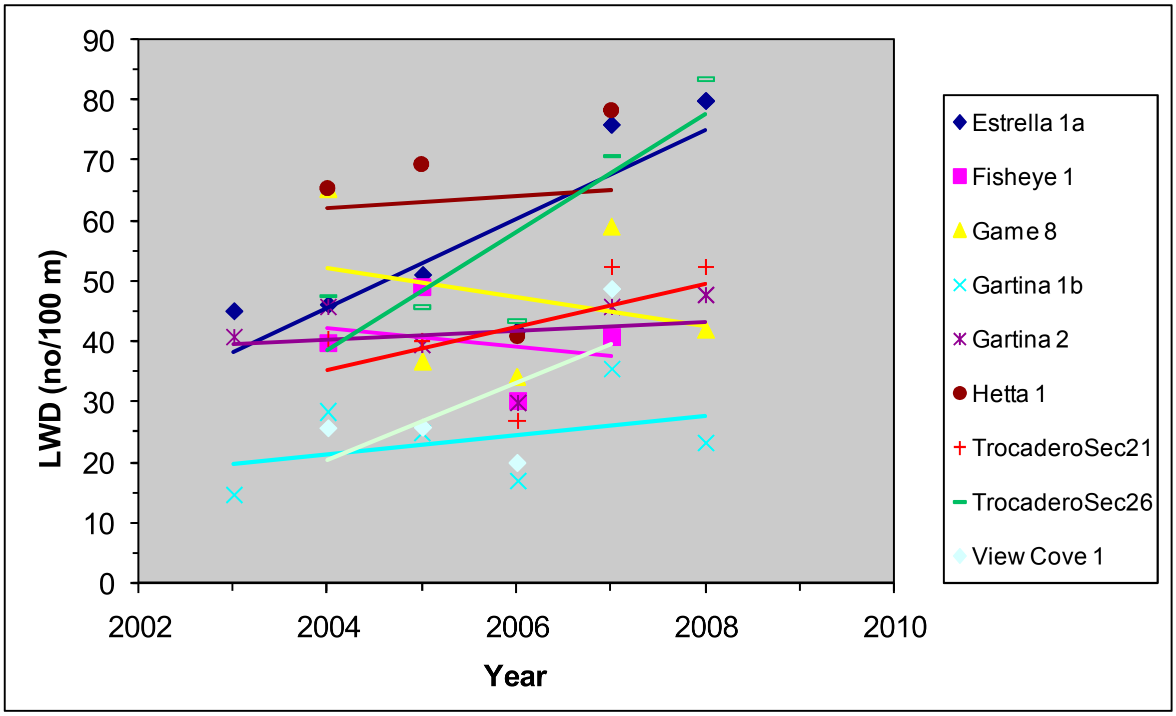
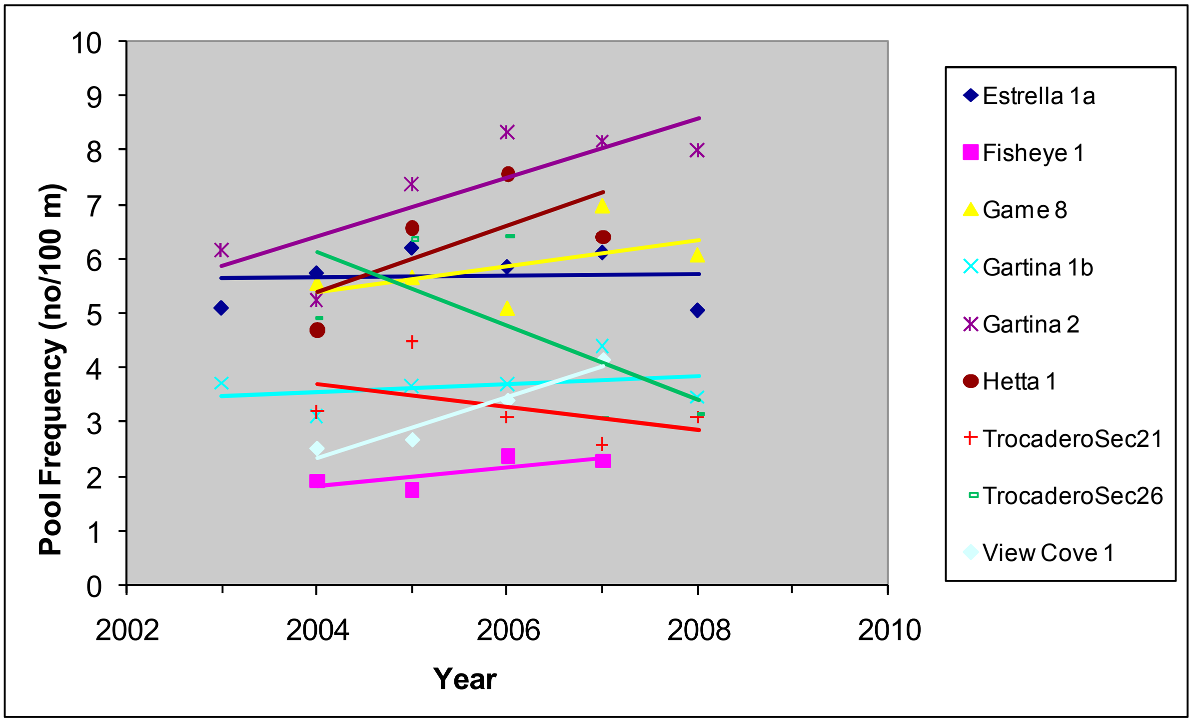


Figure 3. Trends in in-stream LWD density at the new monitoring sites.



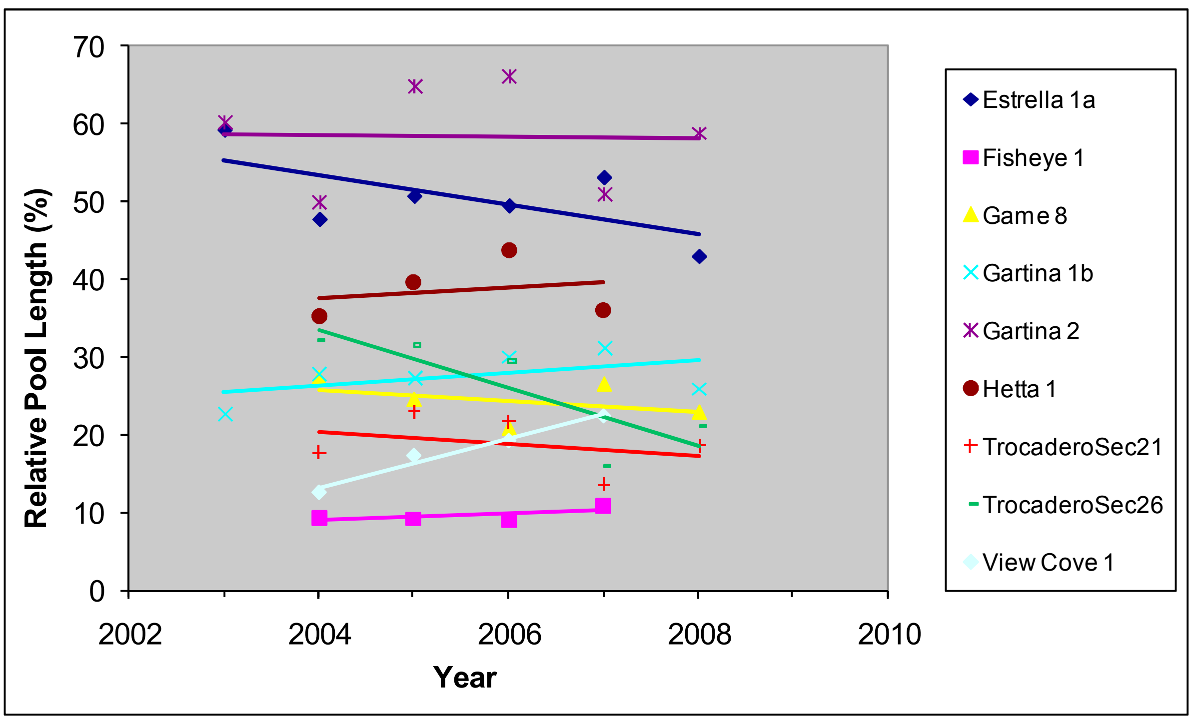


Figure 4. Trends in pool frequency and relative pool length at the new monitoring sites.

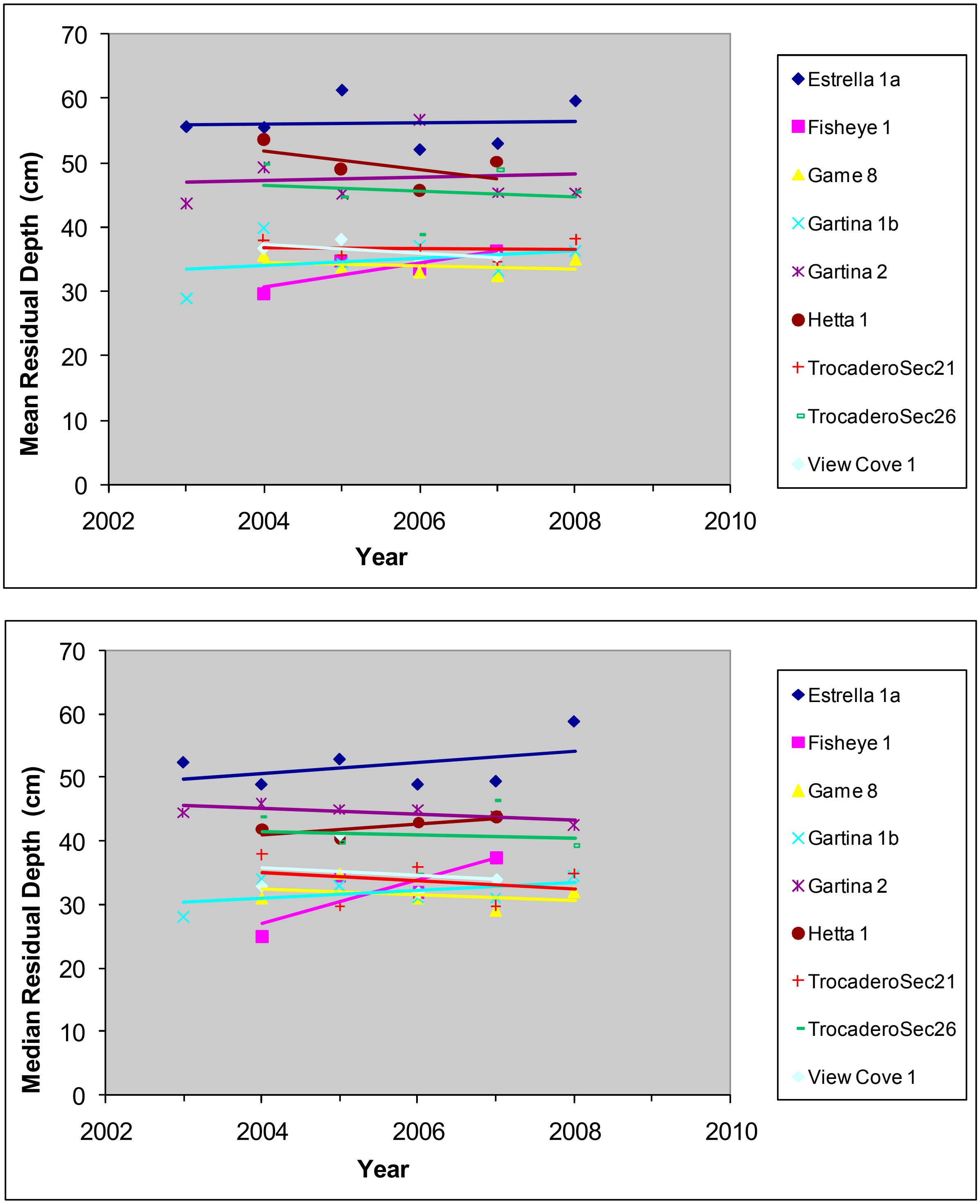


Figure 5. Trends in mean and median residual pool depth at the new monitoring sites.

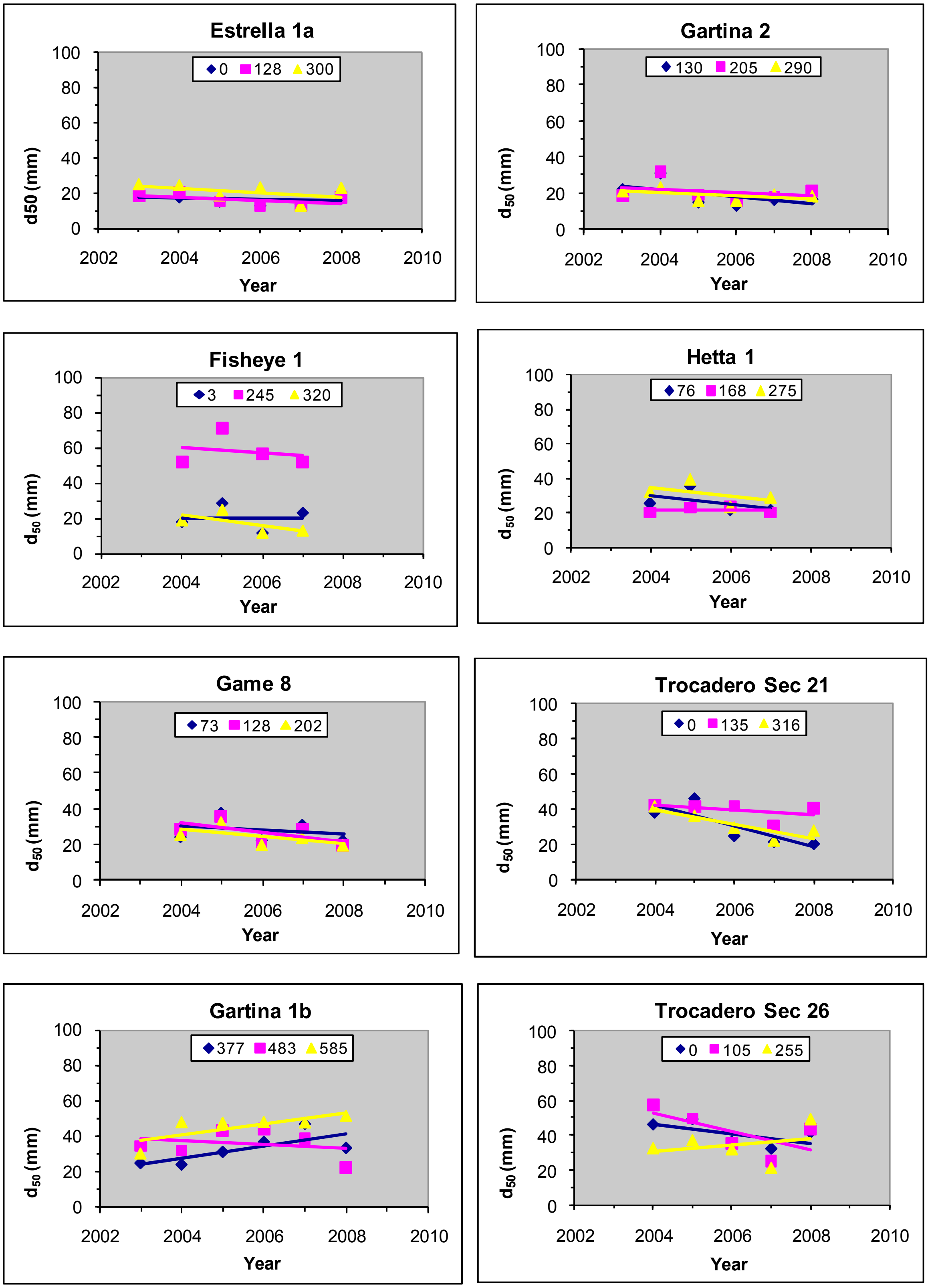


Figure 6. Trends in substrate size d_{50} at the new monitoring sites.

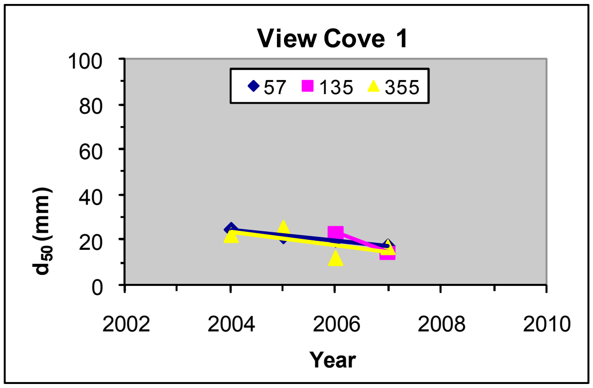


Figure 6. **(continued).**

5.0 FUTURE MONITORING

Over the past several years, we shifted to an alternating (pulsed) monitoring schedule. We established two monitoring 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 and 2008, we continued monitoring at most of 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 2008 we learned that logging was implemented at one of the new study reaches (Gartina 2), will be delayed indefinitely at two reaches (Game 8 and Gartina 1b), and is no longer proposed for two reaches (Estrella 1 and Hetta 1). When we established these sites in 2003/2004, all of the sites were expected to be conventionally logged and to have 66-ft buffers. However, variability in the timber market has caused changes in the harvest schedule and in the type of harvest (conventional or helicopter) for many areas. Consequently, several study reaches may not be harvested in the foreseeable future, two reaches received helicopter only harvest, and buffer strip widths/lengths are not uniform among the reaches with conventional harvest.

The shift in logging plans and harvest intensity has caused us to adjust our monitoring scheme. First, we propose to continue monitoring at the helicopter sites (i.e., Fisheye, View Cove) and at the unlogged sites (i.e., Estrella, Gartina 1b, Game 8, and Hetta) 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., low disturbance from windthrow and LWD recruitment) would be considered reference sites, and those with more disturbance would be treated accordingly. Second, we propose that monitoring during 2009 be continued at the ten annual-panel monitoring sites (Table 8) to provide a continuous record of inter-annual variability. Third, we recommend that the pulsed monitoring schedule (survey of all 22 sites) resume in 2010 to facilitate an initial evaluation of harvest effects at the new sites and to quantify the long-term trends for all of the old monitoring sites. The pulsed monitoring should continue for two to three years (2010-2012) to fully capture and document the trends in habitat conditions. The need for future monitoring beyond 2012 would be evaluated at that time.

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.

Area	Stream	Ch. Type	Harvest Year	Existing Monitoring Schedule 94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	Proposed Schedule 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	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	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	X							
Craig	Coco 2a	MM	2003	X	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	—				X							X	X	X	X	X							
Hoonah	Gartina 1b	MM	—										X	X	X	X	X	X							
Hoonah	Gartina 2	FP	2008										X	X	X	X	X	X							
Craig	Estrella	FP	—		X	X	X						X	X	X	X	X	X							
Craig	Fish Eye	MM	2007											X	X	X	X								
Craig	Hetta	MM	—											X	X	X	X								
Craig	Trocadero S21	MM	2007											X	X	X	X	X							
Craig	Trocadero S26	MM	2007											X	X	X	X	X							
Craig	View Cove	MM	2007											X	X	X	X								

Legend: Unlogged (green) | Conventional Logged (yellow) | Helicopter (orange)

6.0 REFERENCES

Alaska Department of Natural Resources (ADNR). 2000. Alaska forest resources and practices regulations. ADNR, Division of Forestry, Juneau, Alaska.

Alaska Department of Natural Resources (ADNR). 2003. Alaska forest resources and practices act. ADNR, Division of Forestry, Juneau, Alaska.

Bisson, P. A., J. A. Nielson, R. A. Palmason, and L. E. Grove. 1982. A system of naming habitat types in small streams, with examples of habitat utilization by salmonids during low stream flow. Pages 62-73 *in* N. B. Armantrout, editor. Acquisition and utilization of aquatic habitat inventory information. Proceedings of a symposium held October 28-30, 1981, Portland, Oregon, Western Division, American Fisheries Society. American Fisheries Society, Bethesda, Maryland.

Bryant, M. D. 1995. Pulsed monitoring for watershed and stream restoration. Fisheries 20:6-13.

Harrelson, C. C., C. L. Rawlins, and J. P. Potyondy. 1994. Stream channel reference sites: an illustrated guide to field technique. General Technical Report RM-245, U.S. Department of Agriculture Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Hennon, P. E., M. H. McClellan, and P. Palkovic. 2002. Comparing deterioration and ecosystem function of decay-resistant and decay-susceptible species of dead trees. Pages 435-444 *in* W. Laudenslayer, P. Shea, B. Valentine, C. Weatherspoon, and T. Lisle, editors. Symposium on the Ecology and Management of Dead Wood in Western Forests, 2-4 November 1999, Reno, Nevada. General Technical Report PSW-GTR-181, U.S. Department of Agriculture Forest Service, Albany, California.

Lisle, T. E. 1987. Using “residual depth” to monitor pool depths independently of discharge. Research Paper PSW-394, U.S. Department of Agriculture Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, California.

Martin, D. J. 1994. Fish habitat and channel conditions of nine streams in forested lands of Southeast Alaska and Afognak Island. Report of Pentec Environmental, Inc., to Sealaska Corporation, Juneau, Alaska, and Alaska Forest Association, Ketchikan, Alaska.

Martin, D. J. 1995. A preliminary assessment of fish habitat and channel conditions for streams on forested lands of Southeast Alaska. Report of Pentec Environmental, Inc., to Sealaska Corporation, Juneau, Alaska, and Alaska Forest Association, Ketchikan, Alaska.

Martin, D. J. 1996. Fish habitat and channel conditions for streams on forested lands of coastal Alaska: an assessment of cumulative effects, 1995 assessment. Report of Pentec Environmental, Inc., to Sealaska Corporation, Juneau, Alaska, and Alaska Forest Association, Ketchikan, Alaska.

Martin, D. J., 2001. The influence of geomorphic factors and geographic region on large woody debris loading and fish habitat in Alaska coastal streams. North American Journal of Fisheries Management 21:429-440.

Martin, D. J., and L. E. Benda. 2000. Patterns of wood recruitment and transport in Game Creek. Report of Martin Environmental to the Central Council of Tlingit and Haida Indian Tribes of Alaska and Alaska Department of Environmental Conservation, Juneau, Alaska. Community Water Quality Grant No: NP-01-14.

Martin, D. J., and L. E. Benda. 2001. Patterns of in-stream wood recruitment and transport at the watershed scale. Transactions of the American Fisheries Society 130:940-958.

Martin D. J. and R. A. Grotefendt. 2001. Buffer zones and LWD supply. Report of Martin Environmental and Grotefendt Photogrammetric Services to Alaska Forest Association and Alaska Department of Environmental Conservation. Community Water Quality Grant No: NP-01-12.

Martin, D. J., and R. A. Grotefendt. 2005. The effectiveness of standard buffer strips to supply LWD to streams in Southeast Alaska. Report of Martin Environmental and Grotefendt Photogrammetric Services to Sealaska Corporation and Alaska Department of Natural Resources, Juneau, AK. Alaska Clean Water Action Grant No. NA04NOS4190030.

Martin, D. J., and R. A. Grotefendt. 2007. Stand mortality in buffer strips and the supply of woody debris to streams in Southeast Alaska. Canadian Journal of Forest Research 37:36-49.

Martin, D. J., J. A. Kirtland, and C. R. Jackson. 1996. Fish habitat and channel conditions for streams on forested lands of coastal Alaska: an assessment of cumulative effects, 1994 assessment. Report of Pentec Environmental, Inc., to Sealaska Corporation, Juneau, Alaska, and Alaska Forest Association, Ketchikan, Alaska.

Martin, D. J., M. E. Robison, and R. A. Grotefendt. 1997. Fish habitat and riparian stand composition for streams on forested lands of coastal Alaska: 1996 Assessment. Report of Martin Environmental and Grotefendt Photogrammetric Services to Sealaska Corporation, Juneau, Alaska.

Martin, D. J., M. E. Robinson, and R. A. Grotefendt. 1998. The effectiveness of riparian buffer zones for protection of salmonid habitat in Alaska coastal streams. Report of Martin Environmental and Grotefendt Photogrammetric Services to Sealaska Corporation, Juneau, Alaska, and Alaska Forest Association, Ketchikan, Alaska.

Martin D. J., and A. Shelly. 2004. Status and trends of fish habitat condition on private timberlands in Southeast Alaska: 2003 Summary. Report of Martin Environmental to Sealaska Corporation and Alaska Department of Natural Resources. Alaska Clean Water Action Grant No: NA170Z2325.

Martin, D. J., and A. Shelly. 2005. Status and trends of fish habitat condition on private timberlands in Southeast Alaska: 2004 summary. Report of Martin Environmental to Sealaska Corporation and Alaska Department of Natural Resources. Alaska Clean Water Action Grant No: NA04NOS4190030.

Martin, D. J., and A. Shelly. 2006. Status and trends of fish habitat condition on private timberlands in Southeast Alaska: 2005 summary. Report of Martin Environmental to Sealaska Corporation and Alaska Department of Natural Resources, Juneau, Alaska. Alaska Clean Water Action Grant No: NA05NOS4191147.

Martin, D. J., and A. Shelly. 2007. Status and trends of fish habitat condition on private timberlands in Southeast Alaska: 2006 summary. Report of Martin Environmental to Sealaska Corporation and Alaska Department of Natural Resources, Juneau, Alaska. Alaska Clean Water Action Grant No: NA06NOS4190191.

Martin, D. J., and A. Shelly. 2008. Status and trends of fish habitat condition on private timberlands in Southeast Alaska: 2007 summary. Report of Martin Environmental to Sealaska Corporation and Alaska Department of Environmental Conservation, Juneau, Alaska. Alaska Clean Water Action Grant No: 08-R07.

Paustian, S. J., A. Anderson, D. Blanchet, S. Brady, M. Cropley, J. Edgington, J. Frysell, G. Johnejack, D. Kelliher, M. Kuehn, S. Maki, R. Olsen, J. Seesz, and M. Wolanek. 1992. A channel type users guide for the Tongass National Forest, Southeast Alaska. R10 Technical Paper 26. U.S. Department of Agriculture Forest Service, Alaska Region, Juneau, Alaska.

Perkins, S. J. 1999. Landslide inventory and sediment-response study for monitored Sealaska streams. Report prepared by Susan J. Perkins, Consulting Geomorphologists for Sealaska Corporation.

Robison, E. G., and R. L. Beschta. 1990. Characteristics of coarse woody debris for several coastal streams of southeast Alaska, USA. Canadian Journal of Fisheries and Aquatic Sciences 47:1684-1693.

Schuett-Hames, D., A. Pleus, L. Bullchild, and S. Hall. 1994. Timber-Fish-Wildlife ambient monitoring program manual. TFW-AM-94-001, Northwest Indian Fisheries Commission, Olympia, Washington.

Wolman, M. G. 1954. A method of sampling coarse riverbed material. Transactions of the American Geophysicists Union 35(6):951-956.