APPENDIX C: QUALITY ASSURANCE

Appendix C-1. Quality Assurance/Quality Control

Evaluation of Trawl Event Criteria to Characterize Sampling Success

Site Objectives. The QA/QC criterion for accepting a station for assemblage analysis required only that the station be within a subpopulation but more precise field guidelines were implemented to ensure that sampling was conducted close to the assigned coordinates (Table 1). The details are found in the Bight'08 Coastal Ecology Committee Field Operations Manual (Bight'08 Coastal Ecology Committee 2008c). The important specifications are as follows. The trawl was to be taken within 100 m of the pre-assigned site, except at the Channel Islands where it was extended to 200 m. The trawl depth was within 10% of the nominal depth. Trawls were to be towed for 10 minutes, 5 minutes in bay/harbor areas with distance restrictions, at a constant speed of 0.8-1.0 m/s (1.6-2.0 kts). Trawls exceeding 200 m depth were required to use a pressure-temperature archival sensor to monitor and ensure proper “on bottom” times (8-15 minutes).

The ability of the organizations to follow these guidelines was evaluated through post-survey analysis. Agencies had to enter and submit data correctly for proper evaluation. The details the data records are found in the Information Management Plan (Bight'08 Information Management Committee 2008). To minimize transcription errors, a field computer data system (FCDS) tool was made available to participating organizations. Some field crews experienced intermittent problems with the system and fill out datasheets with available data. All trawl events without failure codes had recorded adequate geo-references for analysis.

Distance from Nominal Site. For the survey, 99% of the trawls were within the proper 100 m radius of the nominal coordinates. One site, station 6325, in Dana Point Harbor was between 100-200 m. None of the biological data was excluded from any analysis because of its distance from the nominal coordinate. Since the implementation of post-survey QC reporting, the regional survey has seen a steady improvement of organizations achieving the 100/200 m radius criteria: in 1998 (69%), 2003 (95%).

The 2008 survey implemented a new data system tool within the FCDS to helping crews determine the distance to target and automatically record the minimum value. When intermittent FCDS problems occurred, field crews used other means to determine distance to target (e.g., ask the captain, GIS, reported no value). Post-survey QC checks used three methods to determine minimum distance to target: the FCDS value, nearest GIS distance to a straight line trawl track, and closest distance to start/end points. The best two methods for minimal distance were FCDS (49%) or GIS (50%). Since a boat’s trawl path varies along the depth contour, knowing the latitude and longitude of the start/end points was a viable alternative for determining distance to target. The distance difference between FCDS and GIS method where usually close (80% <=30 m), unless crews made data errors.

Depth Change Criteria. The Information Management Plan (Bight'08 Information Management Committee 2008) did not have a data field that records the nominal depth of the assigned trawl station. Crews were supposed to visit the original coordinates and choose a trawl track that did not very by ±10% of the target depth. Without knowing the target depth, compliance could not be evaluated. An alternative method was used to get an idea of the depth variation during a trawl.

Ninety-eight percent of the trawl tracks were within 10% of the average depth based on start and end depths. The four sites outside the 10% bracket at depths less than 10 m. Minor changes at these shallow depths were considered insignificant, especially to the general assemblage population. Field crews did a good job towing the n*et al*ong isobaths.

Trawl Duration. The previous regional survey, 2003, demonstrated that three categories of trawl duration times need to be recognized: 5-minute tows, 10-minute tows, and trawls deeper than 200 m. For deep water trawls, greater than 200 m depth, field crew times do not match up well with actual net on-bottom times. The 2008 survey had 16% of the trawls, 23 sites, in shallow water (5-minute) areas with limited distance. Of the remaining 10-minute tow sites, 23% (33 sites) were deeper than 200 m.

Trawl times appeared reasonable for five and most ten minute tows (Figure 1). One hundred percent of the shallow water 5-minute tows were near the expected time. Ten minute tows shallower than 200 m ranged between 8-12 minutes with 86% near the expected time. Trawls over 200 m depth were less likely to match time expectations. Times ranged between 6-23 minutes with a poor correlation to depth (p=0.145, Spearman Rank Order). See the pressure-sensor section for further investigation. All 5-minute trawls were normalized to a common 10-minute haul standard for data analysis (see Materials and Methods Chapter) comparability. None of the biological data was excluded from analysis because of excessive crew times.

Distance. Boat distances, start to end points, appeared reasonable for five and many of the ten minute tows (Figure 1). Based on the Field Operations Manual, the expected distance should range between 232-309 m for 5-minute and 464-618 m for 10-minute, trawls.

Five minute tows ranged between 247-357 m with the average and median lengths of 313 m and 309 m, respectively. Forty-eight percent of the 5-minute tows were in the expected distance range. Station 7579 was the shortest, water depth 197 m, and may reflect transcription errors because of FCDS problems. The other short tows (4 sites) were close to the low expected range.

Ten minute tows (< 200 m depth) ranged between 290-887 m with the average and median lengths of 601 m and 569 m, respectively. Fifty-seven percent of the 10-minute tows were in the expected distance range. Seventeen sites were within 100 m of the upper expected range. The 15 sites (>718 m distance) were scattered among three sampling organizations.

Trawls over 200 m depth were problematic in terms of achieving standardized trawl distance. Tows at this depth ranged between 303-1346 m with the average and median lengths of 731 m and 701 m, respectively. The relationship between time and distance should positively correlate with increasing depth because the net takes longer to get to the bottom and lags on the bottom before coming off. Spearman Rank Order correlations show this positive (0.529, p<0.010) relationship. The expectations are that distances should exceed the upper limit of standard 10-minute trawls (618m). Forty-two percent (14 sites) were below this expectation. None of the biological data was excluded from analysis because of distance.

Tow Speed. The general trend was for boats to trawl faster than the recommended speed, 0.8–1.0 m/sec (1.6-2.0 kts). For 5-minute tows, 43% were within range and no site was below the limit. Fifty-four percent of the 10-minute tows were within range and 33 sites were above the limit. For trawls deeper than 200m, 36% were within range and 19 sites were above the limit (58%). This trend was seen in the previous survey. None of the biological data was excluded from analysis because of tow speed.

Pressure-Temperature (PT) Sensor. All organizations submitted PT data. No specific PT manufacture was required. Organizations experienced sensor failure (no downloadable data) in 33% of the trawls, ranging from 0 to 82% failures for each agency.

Information learned from PT data submitted from the 2003 survey, suggested that crews had to lengthen trawl times at depths greater than 200 m to compensate for travel time as the net descended to the bottom and lagged on initial retrieval. For instance, at a 500 m depth station, trawl times should approach 20 minutes to get an equivalent 10 minute on-bottom time for the net (Table 2). The data also suggested that vessels have unique characteristics (i.e., winch speed, wire diameter, captains towing procedure) which must be monitored and adjusted to achieve near 10 minute net-on-bottom times while compensating for environmental factors (i.e., wind, swell, currents).

As shown in the 2008 PT data, 58% of the trawls were within the QA goals set prior to the start of the survey (Figure 2). One organization with extremely long tow lengths were close to meeting the goal of 8-15 minute on-bottom net time. Eighteen percent of the data had bottom times greater than 20 minutes. Some short tow lengths were associated with long on-bottom times. Long bottom times were associated with 6-10 minute tows as reported by the crew (Figure 3). Vessel or crew differences appear to cluster together (Figure 2).

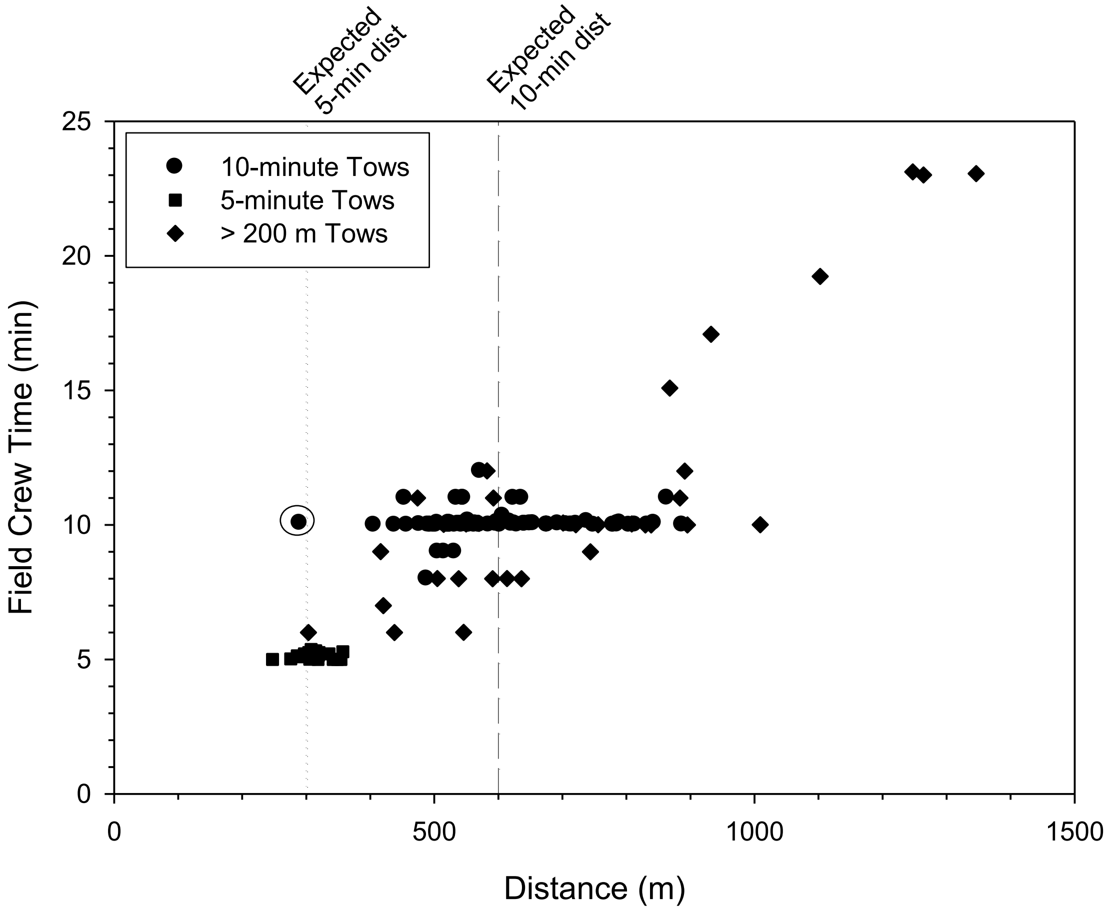

Figure 1. Trawl distance versus boat time results for community data collected during the Bight'08 regional survey. The outlier was circled to illustrate potential transcription errors resulting in improper distance (circle).

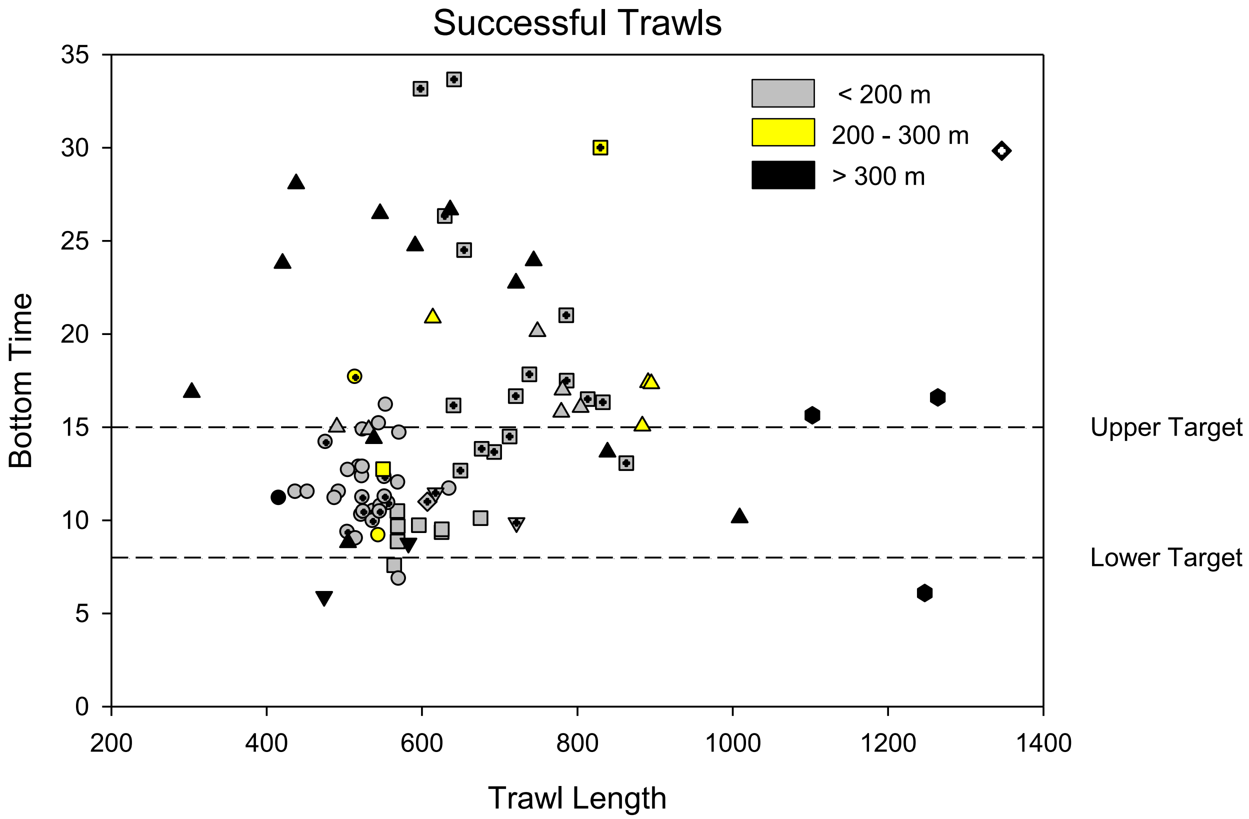

Figure 2. Tow distance versus net on-bottom time (pressure-temperature sensor) for successful trawls during the Bight'08 regional survey. Colors represent depth. Symbols represent vessels and field crews. The upper and lower bounds were the quality assurance goals prior to the survey. Five minute tows omitted from graph.

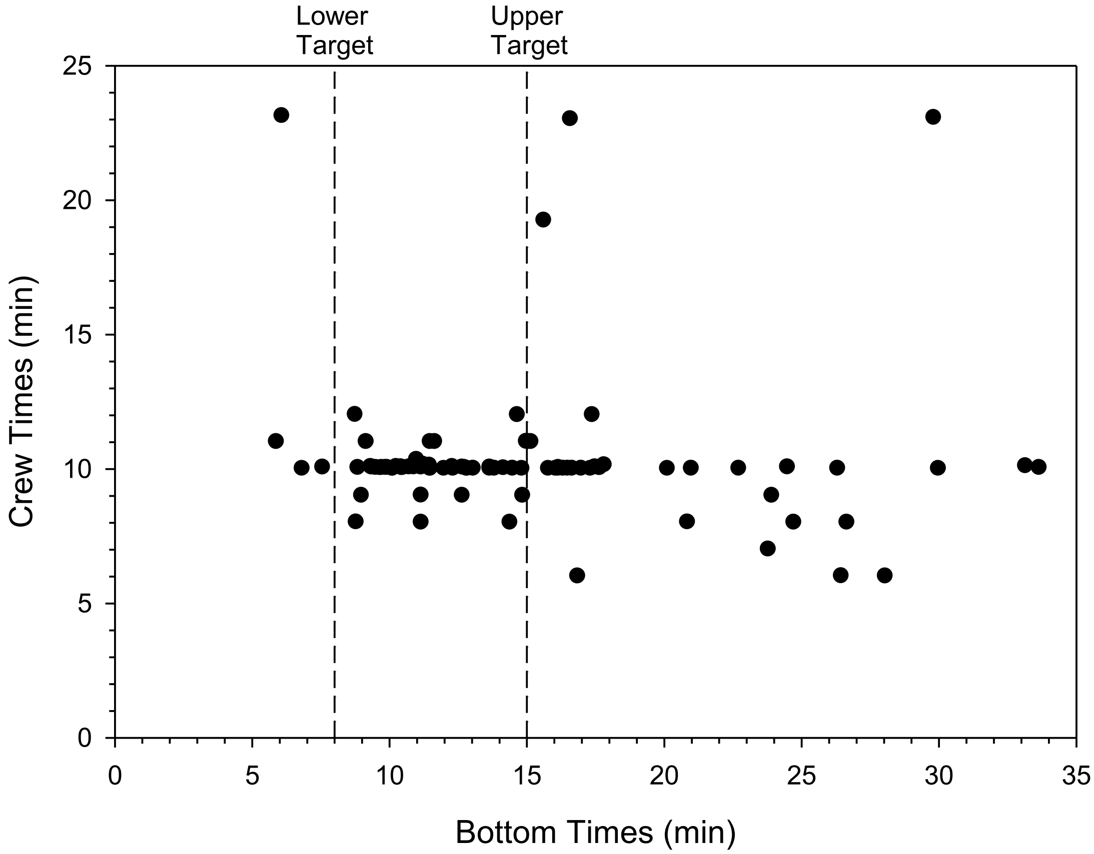

Figure 3. Bottom time (pressure-temperature sensor) versus reported crew times during the Bight'08 regional survey. The upper and lower bounds were the quality assurance goals prior to the survey. Five minute tows omitted from graph.

Table 1. Trawl sample size design compared to actual survey results by subpopulation, plus failure reasons. Three successful marina sites were excluded due to inappropriate substitution.

Area	Strata	Expected	Success	Fail
Offshore	Inner shelf (5-30m)	30	32	7
Offshore	Mid-shelf (30-120m)	30	33	3
Offshore	Outer shelf (120-200m)	30	23	3
Offshore	Upper slope (200-500m)	30	33	1
Embayment	Bays/Harbors	30	19	1
Total		150	140	15

Reasons for Failure	Number
Kelp Bed	3
Obstructions	3
Rocky Bottom	3
Torn Net	2
Irregular Bottom	1
Exclusion Zone	1
< 6 m	1
Improper Distance/Time	1

Table 2. Suggested guide for boat/deck times toward achieving a 10 minute on-bottom net time. Negative values mean the net was on the bottom for a certain amount of minutes. Calculations were based on N = 99.

Station Depth (m)	Depth/Wire Scope[1]	Wire (m)	Winch[2] Time (min)	Wire[3] Depth (m)	Minutes To Bot Lag[4]	Minutes Off Bot Lag[5]	10 Min Trwl Est Deck Time (min)
50	5.0	252	6.12	50.7	-0.05	2.20	7.75
100	4.1	410	9.97	82.5	1.33	2.91	8.42
150	3.6	545	13.25	109.6	3.06	3.62	9.44
200	3.3	668	16.22	134.2	4.99	4.33	10.67
250	3.1	781	18.97	157.0	7.06	5.04	12.02
300	3.0	888	21.56	178.4	9.23	5.75	13.48
350	2.8	989	24.03	198.8	11.47	6.46	15.02
400	2.7	1,086	26.39	218.4	13.78	7.17	16.62
450	2.6	1,180	28.67	237.2	16.15	7.87	18.27
500	2.5	1,271	30.87	255.5	18.56	8.58	19.97

[1] Power function was 16.139219 * (Station Depth $^{-0.297449384}$) based on method protocol.

[2] Average agency winch rate was 41.16 m/min.

[3] Average descent rate was 8.3 m/min. Average lag on bottom decent rate changed +1.6 times.

[4] Used: (Station Depth – Wire Depth) / (Avg Descent Rate * Avg Change Rate Factor).

[5] Used: regression formula: 1.4903252151 + (0.0141874591*Station Depth)) based on Lag Off vs. Depth data.

Appendix C-2. Fish Post-Survey Voucher Check

		Participating Organization									
		1	2	3	4	5	6	7	8	9	All
Trawl Fish Bucket Test Evaluation											
Total Fish Species in Bucket		30	30	30	30	30	30	ND	ND	30	210
Number of species IDs correct		29	30	28	30	29	27	ND	ND	29	202
Number of species IDs incorrect		0	0	2	0	1	3	ND	ND	1	7
Number of species as FIDs		1	0	0	0	0	0	ND	ND	0	1
Number of species IDs attempted		29	30	30	30	30	30	ND	ND	30	209
Bucket FID Evaluation											
Number of FID species attempted		1	0	0	0	0	0	ND	ND	0	1
Number of FID species correct		0	0	0	0	0	0	ND	ND	0	0
Number of FID species incorrect		1	0	0	0	0	0	ND	ND	0	1
Percent of FID species correct		0	0	0	0	0	0	ND	ND	0	0
Bucket Summary											
Percent species as FIDs		3	0	0	0	0	0	ND	ND	0	0
Percent of species IDs correct		93	100	93	100	97	90	ND	ND	97	74
% error in species identification		7	0	7	0	3	10	ND	ND	3	4
Compliance with Accuracy MQO *		N	Y	N	Y	Y	N	N	N	Y	44%
Trawl Fish Voucher Evaluation											
Specimens submitted (includes some photo w/spec)		41	46	58	45	67	40	48	45	45	435
Photo only submitted		1	8	2	0	2	11	3	0	6	33
Lost or missing species		1	0	0	0	0	0	1	0	2	4
Originally submitted as FIDs		0	0	0	0	0	0	5	0	0	5
Total submitted as vouchers/FID/lost		43	54	60	45	69	51	57	45	53	477
Error Types											
Additional species found (no FIDs)											
Clerical/logistical errors **		1	0	0	0	0	0	1	0	2	4
Key characters not in photo voucher		0	0	0	0	0	1	0	0	0	1
Old or Misspelled names		0	0	3	3	0	1	0	1	2	10
Correct but incomplete IDs		0	0	0	0	0	0	0	1	0	1
Incorrect voucher identifications	Acc	4	1	3	0	2	0	8	2	3	23
Trawl Fish FID Evaluation											
Total FIDs		0	1	1	0	0	0	7	1	4	14
Additional species found (FIDs only)											
Old or misspelled names	N/A	0	0	0	0	0	0	1	0	1	2
Correct but incomplete IDs	N/A	0	0	0	0	0	0	0	1	0	1
Incorrect identifications	N/A	0	0	0	0	0	0	2	0	1	3
No identification attempted	N/A	0	0	0	0	0	0	0	0	0	0
Voucher Summary (including FIDs turned into vouchers)											
Total vouchers		42	47	57	44	67	40	47	45	45	434
Total data Changes		4	1	4	3?	2	0	11	4	4	30
% Voucher Submission Compliance		98	100	100	100	100	100	98	100	96	99
% Identification Precision ***		88	98	89	93	97	95	81	91	84	91
% error in voucher ID accuracy		**9**	2	5	0	3	0	**15**	4	**6**	5
Compliance with Accuracy MQO*	N/A	N	Y	Y	Y	Y	Y	N	Y	N	67%

Appendix C-3. Invertebrate Post-Survey Voucher Check

	Participating Organization									
Data modification type	1	2	3	4	5	6	7	8	9	All
Invertebrate Bucket Test Evaluation										
Total Fish Species in Bucket	ND	30	30	30	30	30	ND	ND	30	180
Number of species IDs attempted	ND	30	28	25	23	23	ND	ND	19	148
Number of species as FIDs	ND	0	2	5	7	7	ND	ND	11	32
Number of species IDs correct	ND	24	26	24	23	18	ND	ND	11	126
Number of species IDs incorrect	ND	6	2	1	0	5	ND	ND	8	22
Percent of species IDs correct	ND	80	93	96	100	78	ND	ND	58	85
Percent of species IDs incorrect	ND	20	7	4	0	22	ND	ND	42	15
Percent species as FIDs	ND	0	7	20	30	30	ND	ND	58	22
Number of FID species attempted	ND	0	0	4	6	2	ND	ND	10	22
Number of FID species correct	ND	0	0	3	1	2	ND	ND	4	10
Number of FID species incorrect	ND	0	0	1	5	0	ND	ND	6	12
Percent of FID species correct	ND	0	0	75	17	100	ND	ND	40	45
% error in species identification	ND	20	7	4	0	22	ND	ND	42	15
Compliance with Accuracy MQO *	ND	N	N	Y	Y	N	ND	ND	N	N
Trawl Invertebrate Voucher Evaluation										
Specimens submitted	32	61	58	48	96	53	55	31	34	468
Photo only submitted	0	10	0	0	0	12	5	1	0	28
Lost or missing species	0	2	3	0	0	1	1	0	2	9
Total submitted as vouchers	32	73	83	48	107	74	92	47	38	594
Additional species (exclude FIDs)	1	0	0	0	0	0	0	0	0	1
Old or Misspelled names	0	1	1	2	2	3	2	1	3	15
Correct but incomplete IDs	2	1	3	0	0	1	1	0	1	9
Key characters not in photo voucher	0	0	0	0	0	0	0	0	0	0
Incorrect voucher identifications	3	6	1	2	13	8	5	0	1	39
Inappropriate inclusion (OOH)	0	3	1	0	9	1	0	1	1	16
FID Evaluation										
Originally submitted FIDs	0	0	0	0	10	8	31	14	0	63
Total FIDs (include additional sp.)	0	0	0	0	11	11	32	15	0	69
Old or misspelled names	0	0	0	0	1	0	1	0	0	2
Correct but incomplete IDs	0	0	0	0	0	5	24	7	0	36
Incorrect identifications	0	0	0	0	3	2	5	2	0	12
No identification attempted	0	0	0	0	0	4	0	0	0	4
Inappropriate inclusions (OOH)	0	0	0	0	4	0	0	0	0	4
Summary										
Total data Changes	5	11	7	4	23	14	8	2	8	82
% Voucher Submission Compliance	100	97	96	100	100	99	99	100	95	98
% error in voucher ID accuracy	9	8	1	4	13	12	7	0	3	6
% Identification Precision	94	93	94	96	89	93	96	96	87	93
Compliance with Accuracy MQO*	N	N	Y	Y	N	N	N	Y	Y	N

% Compliance = % species with vouchers submitted.

Precision -- No. misspelled names; no. old names; No. incomplete IDs;

Appendix C-4. Critique of the Invertebrate Post-Survey Voucher Check

QC Results of Voucher and FID Trawl Invertebrates in Bight ‘08

By D. B. Cadien (LACSD), 21 September 2009

The purpose of this review is improved quality assurance for the next regional trawling effort. It should also help agencies evaluate and interpret their performance in B’08. Areas where that performance fell below their objectives, or those of the regional effort as a whole, can be identified and serve as a template for efforts at improvement. One observation needs to be made prior to consideration of the review statistics for B’08. Labeling in this effort was sadly deficient. Almost no one provided clear and complete labels listing the generating agency, the B’08 station, the collection date, the collection depth, the status (voucher or FID), provisional identification of the lot, and the specimen count. This provided considerable confusion in some cases for the reviewing team, and made record keeping rather difficult. Accurate and complete internal labeling is essential, and accurate external labeling is highly desirable. Please be more attentive to such requirements in future.

General Performance

All agencies participating in the B’08 trawling effort did a good job handling the QC and FID process this time. Several markedly improved performance seen in B’03. Once again, however, we narrowly missed our MQO of 95% correct identifications of vouchers, with an aggregate error rate of 6.37%. This is a slight improvement from B’03.

There was only one additional vouchers created during the QC reexamination by splitting of voucher lots. None of the vouchers identified to species level consisted of more than one species. The lot split was identified only to order, and should have been considered an FID rather than a voucher. This is a significant improvement from B’03, and shows added care in the selection and preparation of vouchers. The addition of lots during QC examination always raises a certain level of ambiguity if two or more specimens are recorded under a single identification. In the usual case, however, the added species is associated with the primary voucher as a commensal or parasite, and there is no confusion in the database.

Three metrics are used in the accompanying table: % Voucher Submission Compliance, % error in voucher identification, and % precision in voucher identification. There is an MQO defined in B’08 for only one of these, % accuracy. It is likely that MQO’s will be established for all three in B’13.

While the FID submissions are not subject to error evaluation, and are not used to generate compliance statistics, several aspects of FIDs submitted are noteworthy. First, there were far fewer in B'08 than in B'03. None-the-less the coverage of what was included in FIDs seemed very appropriate, and the FID/Voucher separation was very good. In only one case was a lot labeled simultaneously as an FID and as a Voucher, and in another a lot labeled voucher should have been an FID. Second, the majority of FIDs were correctly but incompletely identified, with less than 20% of them incorrectly identified. The FIDs seem to be serving the intended purpose of allowing uncertainties in the field to be resolved in the laboratory so that field data become fully interpretable. All participants are to be applauded for this, as recognizing when to return something for further action in the laboratory is an essential and difficult part of the field decision-making process.

Both the number of voucher lots and the number of FIDs decreased in B'08 relative to B'03, speeding the process of reexamination by the QC team. The group involved in B'08 included Don Cadien, Ron Velarde, John Ljubenkov, Megan Lilly, Lisa Haney, Tim Stebbins, and Steve LePage. This review is an effort to apply the results of their examinations to provide Quality Assurance training in preparation for the next iteration of regional monitoring in 2013.

Performance by Category

Missing Vouchers. In several cases vouchers were indicated as taken, but were not present among the materials submitted to SCCWRP. Both physical and photo vouchers were involved. This seems a little careless, but these constituted only 1.6% of the total voucher count. Still, elimination of such losses should be a target of future QC effort. There is fortunately no evidence that species encountered in the field were not vouchered through oversight. This speaks to good on-board record keeping among the field crews.

% Voucher Submission Compliance. There is no MQO for this in B'08, but there will probably be one in B'13. It is reasonable to expect an MQO of 95% or more for this parameter, and a 98% goal would not be inappropriate. Only one of the nine agencies did not reach the 95% level, but three fell below the 98% level. Had either of the two potential MQO targets been in effect in B'08, they would have been met overall. Four of the nine agencies had 100% compliance, a goal all participants should attempt.

Total Data Changes. This is a parameter which affects the production of the final corrected database. Fewer changes are always desirable, although there is no set target. Of the 560 database voucher records, 82 (14.6%) required modification of some type. This includes deletions of inappropriately included taxa, corrections of misspellings, corrections of nomenclature, additional precision in identification, and correction of incorrect identification. We should all strive to reduce the number of changes required by the QC effort in future. FID information is not included in this calculation, but adds to the net changes required to the database.

% Error in Voucher Identification. This is the program measure of accuracy in identification. It includes only those vouchers which were incorrectly identified, not those with errors of spelling, nomenclature, incompletion, or inappropriate inclusion. The established MQO for accuracy is 95%, and %error ranged from 0 to 13.27% among the participants. There was a slight overall decrease in error rate from B'03, but considerable room for improvement remains. Those with higher error rates should attempt to address their particular problem areas prior to the next iteration of regional monitoring. If this percentage error is expressed as a fraction of the total vouchers for the agency the range is narrowed, although some agencies with few vouchers still had % error in identification above the group average. Several topic areas of broad interest will be discussed later.

Compliance with Accuracy MQO. A simple did/did not binary representation of each agency achievement of the MQO of 95% accurate identifications.

% Correct but incomplete names. A measure of precision. Identifications in this category are not incorrect, but are not as precise as is allowed by the condition of the specimens. Vouchers submitted at genus or above and not modified in the QC reexamination do not figure into this measure. Values for individual agencies ranged from 0 to 15.21 in the B'08 vouchers, with a composite of 4.2%. A precision MQO contemplated for B'13 would include this along with several other precision related metrics in a single identification precision measure. Agencies should use this information to target specific identification areas for additional preparation prior to the next regional trawling effort, when a precision MQO is likely to be in force.

% Identification Precision. This includes the number of cases of inappropriate inclusion, of old or misspelled names, and of correct but incomplete IDs expressed as a percentage of the total of vouchers submitted. These three parameters are all considered to be precision rather than accuracy related, and are combined into a single precision metric here. It is contemplated that this will be used again in future regional efforts, once an MQO for identification precision is established in the QC design. A reasonable MQO for precision would be 95%, as has already been established for accuracy.

Precision in B'08 using this metric ranged from 87.18 to 95.82 %, with three of the agencies being at 95% or better. The aggregate precision was only 92.85% in B'08. The easiest way of improving this is exclusion of taxa inappropriate to demersal trawling effort: those which are infaunal or holoplanktonic. For instance, precision for Agency D would have increased from 88.78 to 97.96% if they had not submitted any inappropriate vouchers. Similarly, increased attention given to nomenclatural currency and spelling in data submission might have increased the precision for Agency I from 87.18 to 94.87. These should be relatively accessible fixes, not requiring the additional training needed to reduce the level of correct but incomplete identification. Most of the agencies are close to achieving an MQO of 95% precision in the current data, and should one be established in B'13, it should be attainable.

FID submissions

Information on the FIDs is primarily intended to give agencies a relative measure of their performance vis-a-vis other agencies in the regional effort. None of the FIDs are errors, even those with incorrect IDs. All fulfill the purpose of allowing additional effort in the laboratory to refine taxonomic evaluations in the field. The return of FIDs helps guarantee that the field data base has maximum reliability. Retention of FIDs in cases of uncertainty in the field is to be highly recommended. Such actions, however, also require that additional effort be expended in the laboratory to resolve the identification uncertainty in the FIDs. Most FIDs should be resolved by the originating agencies, with an insoluble residue going to the QC reexamination team for resolution.

The considerable decrease from B'03 in the number of B'08 FIDs unresolved and requiring attention from the QC panel was welcomed by that group. It shows that most, if not all, of the agencies have increased their effectiveness in both field and laboratory invertebrate identification. It probably also reflects increased familiarity with species from deeper sites not normally included in agency monitoring programs.

PROBLEM AREAS

Two specific problem areas were found in the QC process: identification of *Brisaster*, and identification of *Parastichopus*. Both these genera are large, numerous, and typically handled in the field rather than returned to the laboratory. Problems revealed during the QC process cast doubt on the evenness and accuracy of the field species determinations. As not all of the specimens were returned as vouchers or FIDs, dealing with these problems in the resulting database presents complications.

Brisaster latifrons

Brisaster townsendi

Brisaster sp

Examination of the voucher lots provided by the participant agencies showed that misidentifications were frequent, despite considerable QA cross-training efforts since Bight ’03. Discrimination of the two nominal taxa is difficult, and methodological differences between observers can lead to contradictory identifications. Reidentification efforts by the same observer can also lead to different identifications. Added to this is the high likelihood that the two forms hybridize in the SCB, a zone of distributional overlap. Examinations off San Diego have suggested that there is a depth separation between the two forms, with *B. townsendi* occurring deeper, but this did not hold in some other areas (Santa Barbara Channel for instance). The patterns of interfingering of the two forms, with *B. latifrons* reaching its southern distributional limit in the SCB, and *B. townsendi* reaching its northern limit, appear to be complex and counterintuitive. Rather than anti-tropical emergence, as one would anticipate, *B. townsendi* seems to undergo antitropical submergence. No preponderance of *B. latifrons* in the north and the reverse in the south was seen, populations in the SCB do not appear to be distributed along a clear geographic gradient. We must also entertain the possibility (pending molecular clarification yet to come) that the two species are indeed synonyms, as they were treated for nearly 70 years. Given all these problems it seems unavoidable that effort between agencies would be uneven, and that the database should be modified to reflect this. I would suggest that the analytical database be standardized to *Brisaster* spp for all three record types. Some slight loss of precision would result, but since the current data is imprecise because of identification problems, there would be no net loss. Retaining species level identifications for those agencies which did not have identification problems in the Voucher and FID QC examination would only weaken the analysis, and should not be attempted.

Parastichopus californicus

Parastichopus sp A

Parastichopus sp LA2

Parastichopus johnsoni

Parastichopus leucothele

Parastichopus sp

All six of these taxa were reported in the submitted data. Several of the identifications were, however, modified based on the FID or QC reidentifications. *P. johnsoni* and *P. leucothele* records were both based on single small individuals, and were modified to *P.* sp to reflect their juvenile and probably insufficiently mature state of development. In several cases animals identified in voucher or FID submission as *P. californicus* or *P.* sp A proved to be a previously unrecognized new form, *P.* sp LA2. In several cases these were considered to be odd forms of the nominal taxa, and were collected on that basis. Final identification of these animals remands examination of the ossicle complement to confirm identifications based on external features. As yet there is no indication that populations of the various species occur together, but their depth ranges do not preclude this. QA efforts to disseminate the description of *P*. sp A in 2003 do not seem to have been sufficient to allow participating agencies to accurately identify it. It seems to have been treated as a "not *P. californicus*" field taxon, into which members of the newly recognized *P*. sp LA2 were thrown by several agencies. Both taxa have had voucher sheets prepared and disseminated among the participating agencies. Unfortunately *P*. sp LA2 was not recognized prior to examination of the vouchers, so field data did not list this taxon.

Voucher photographs purporting to be *P. californicus* or *P*. sp A are available to document the live appearance of *P*. sp LA2. It does differ from the other two forms, but not so markedly that biologists not used to seeing them would be able to recognize them without fail. Photographs of all forms are available, but must still be combined with ossicle examination for clear differentiation of species. The ossicle measurements all overlap to some extent, and all species have similar ossicles. Use of multiple metrics derived from the ossicles, however, can clearly differentiate the species. The QC data suggest that laboratory confirmation based on ossicle preparation was often not performed. It is possible that still more species in this genus are present along the West Coast. Roger Clark of NOAA has supplied photographs of an animal which does not quite match any of the species listed above, but was not able to provide ossicle data to support its differentiation. His photos were of a species commonly taken to the north off Oregon and Washington, but perhaps not from California.

All of these difficulties suggest that for the purposes of the analytical dataset the various *Parastichopus* (with the exception of *P. parvimensis*, which does not seem to be confused with the others) be treated as one taxon. I would suggest that any records of the five forms listed above be modified to *Parastichopus* spp in the analytic dataset.

AREAS WHERE IDENTIFICATIONS WERE PRIMARILY LABORATORY

Additional problem areas had to do with items normally returned as vouchers or FIDs where field identification and disposal of specimens is not a major issue. The database is correctible based on the returned specimens. Such areas, where many or most identifications were either correct but incomplete or incorrect were:

Aphrodita spp.

Neosimnia spp.

hermit crabs

sponges

hydroids

ectoprocts

Current practice, as evidenced in the B'08 review, seems appropriate, and is well applied by the participating agencies. Return of all such materials as either vouchers or FIDs might be contemplated for B'13.

Appendix C-5. Standardizing Trawling Methods in Southern California

Standardizing Trawling Methods in Southern California

By Dario W. Diehl, M.J. Allen, and Ken Schiff.

ABSTRACT

New technology has enabled the critical evaluation of standardized scientific trawling methods. The new technology consists of miniaturized, data-logging, pressure-temperature sensors attached to trawl doors. Eight different vessels with varying winch wire diameters sampled 110 sites in depths ranging from 10 to 463m. All agencies estimated 10 min bottom time utilizing similarly designed cone-shaped, 25m otter trawl nets. Pressure sensor data indicated two decent scenarios: one while the wire was being letting out and the other during the timed 10 min tow, but before the net actually contacted the bottom. Pressure sensor data also indicated two types of time lags: the time before the net touched bottom at start of trawl and time before the net came off the bottom during retrieval. The average descent rate for the study was 8.2 m/min, ranging from 2.3 to 20.9 m/min. The lag to bottom descent time ranged up to 7 min. At depths greater than 150 m, the average lag time increased with depth. The average lag time off the bottom during net retrieval ranged up to 18 min also increasing with depth. Assuming an acceptable 10 min trawl can vary between 8 – 15 min on-bottom time, 69% of the sites had successful on-bottom trawl times for water depths shallower than 250 m. These depths are consistent with most routine monitoring programs in the SCB. However, there was limited success in trawls deeper than 250m, a habitat receiving greater scientific effort. A guideline for field crews was created to improve the accuracy of on-bottom trawl times that was built upon a model of descent rates, lag to bottom, and lag off bottom using the pressure sensor data from this study. Because the new pressure sensor technology is relatively inexpensive, the sensors could be used on every trawl and deck-side data readers could help confirm on-bottom times at sea.

INTRODUCTION

Trawl surveys of marine ecosystem communities have been documented for over 100 years in the southern California Bight (SCB). At least 1,000 species of benthic fish and invertebrates have been captured in trawls from the SCB (Cross and Allen 1993, Thompson et al 1993). The earliest surveys were recorded by the Albatross Investigations in 1889 (Moring 1999). For the last 40 years, trawling has also been the mainstay of marine biological monitoring of the SCB mainland shelf (Allen 2006). Trawl monitoring has been used to assess the impacts of municipal waste discharges (Stull and Tang 1996), power generating stations (MBC 2003), coastal development (Schiff et al. 2000), bioaccumulation for ecological risk (Allen et al 2002), and climate change (Conners et al 2002, Hamazakia et al 2005), amongst others.

The trawling equipment for commercial and scientific purposes is much different. Commercial trawlers use larger nets and coarse mesh sizes specifically to capture large quantities of market species (Allen 2006, CDFG 2008). Scientific trawlers, in contrast, use smaller nets and finer mesh sizes to target fish species that respond to human impacts (Carlisle 1969, Mearns and Stubbs 1974, Mearns and Allen 1978). As opposed to commercial trawlers, the purpose of the scientific trawling is to capture a representation of the dominant community.

Scientific trawling on the mainland shelf of the SCB has been standardized for at least 30 years (Mearns and Stubbs 1974). Most monitoring agencies report data based on a single wrap (one cable), 10 minute, and small otter trawl with a 25 ft. net opening. This consistency enables data comparability over extended time series at small spatial scales such as an offshore discharge (Stull and Tang 1996). However, the consistency among scientists also enables conjoining data sets from different agencies to make larger spatial scale assessments of benthic fish condition (Allen 2002, 2007). These large scale assessments provide additional value such as the ability to assess fish migration and movement (Allen 2006), fish assemblage alterations due to coast-wide changes in oceanographic condition (Allen 2004), and responses to periodic invasions (Jan Stull's ref).

Conjoining scientifically-collected trawl data sets is contingent on knowing that the trawls were all collected in a similar fashion. While tremendous effort has been expended to ensure similarity in technique (i.e., Bight'08 Coastal Ecology Committee 2008), small deviations in net or door manufacture, wire type, boat and crew, can all contribute to inconsistencies among agencies. To complicate potential inconsistencies, most of the scientific monitoring over the last 30 years has focused on depths between 30 and 120m, but environmental managers and the public are widening their questions about ecosystem health. Monitoring programs are being asked to trawl as shallow as 5m and as deep as 500m. Techniques necessary for standardizing a 10 min trawl for this wide range in depth is still uncertain.

New technology is enabling a critical assessment of standardized trawling times at multiple depths. The goal of this study is to use this new technology to help standardize trawl times and ensure consistent on-bottom sampling regardless of depth. This will be done using an empirically-based model of trawl depth, speed, and wire out (scope). The new technology consisted of pressure sensors capable of a wide depth range. Previously, pressure sensors were bulky and costly to lose. Technological advances have brought down the price, miniaturized their size, and created compact data storage devices. This allowed for the pressure sensor to be mounted directly on trawl doors and used to map decent, on-bottom, off-bottom and ascent for over 100 trawls.

METHOD

The cone-shaped otter trawl nets used in the study had a 7.6 meter (25 ft.) headrope and a body-mesh not exceeding 3.8 – 5.0 cm (1.5 – 2.0 in), stretched mesh, with a fine-mesh liner (0.6 – 1.3 cm or 0.25 – 0.5 inch) inside the cod-end to retain juvenile fishes. The headrope was fitted with small through-hole oval floats, 12 cm or 5 inches, able to withstand pressure at 500 m water depths. The footrope was fitted with a chain, trickling or short looping setup. The net tapers down to the cod-end for an overall length of approximately 9.9 m (32.5 ft). The net was attached to a pair of wooden doors, 16 kg each (35 lb, dry), left and right, fitted with steel shoes or runners. The net was towed with a pair of swivel-mounted bridles that are three times the headrope length (23 m or 75 ft). This setup gives a working net opening of 4.9 m (16 ft) under tow conditions.

The traditional standardized trawling protocol was based on a standard 10 minute tow (Mearns and Allen. 1978). Field crews toss (shoot) the net and doors off the stern in a controlled manner to prevent entanglement at boat speeds of up to 2.1 m/s (4 knots). A winch lowers the net with wire using a scope-to-depth ratio range from 5:1 in shallow water (5 – 20 m) to 2:1 in very deep water (700 – 900 m). Once the proper scope ratio was achieved, the boat slows to approximately 1 m/s (2.0 knots) and field crews begin their 10 minute tow based on deck times. Once completed, the net was brought aboard the boat while captains maintained their speed to minimize animal lose from the net. Crews check door runners for evidence of bottom contact (i.e., sediment, shiny metal). The catch was subsequently processed by enumeration, length measurements (fish only), and weights. Based on the protocol, a standard 10 minute trawl distance approximates 600 meters and covers 2940 square meters.

The study had seven participating organizations that used seven different vessels. Winch wire varied in diameter from 6.4 – 13 mm (0.25-0.5 inch). The drag of the net and doors mitigates some of the effects of the wire weight, diameter and scope ratio, so the net does not drop straight down. Captains were asked to follow isobaths (± 10% of the target depth). The trawl path had to pass within 100-200 m of the assigned coordinates.

The study selected one manufacture to furnish sensors to all field crews. Sensor (temperature and pressure) specifications included the ability to withstand water pressures of 500 meters (51.7 bars or 749.5 psi) and record data every 2 – 4 seconds. The epoxy coated sensors were small, 3 cm by 2 cm, and data was downloaded through an optical pen-reader. Small holes were cut into the otter boards for the sensors and secured in place with a small piece of Plexiglas.

Acceptable pressure traces had to approximate boat fathometer records and have associated biological community data. Of sensors that worked properly, data was within 2% of the depth reported by in-survey boats. In addition, traces had to show the descent, on-bottom, and ascent characteristics of the net. Minor pressure spikes from the sensor were acceptable and limited to on-bottom portion of the trace. Typically, sensor failure showed an abrupt change in pressure and never recovered during the trawl. These data were discarded.

The data was independently categorized into two forms, sensor response and field crew activities. The categories were surface, decent, bottom, and retrieval. Sensor response was based solely on the pressure trace as it traveled from the boat surface to the bottom, recording stable readings on the bottom, then retrieval. Transition points, including when the net hits or comes off the bottom, were based on best professional judgment due to uneven bathymetry and subtle, rather than sharp, rise off the bottom. The crew category was based solely on shipboard records of timed activities (i.e., net over, start and end trawl, net on deck). Each trawling organization time corrected and categorized their pressure traces. Coherent with time matching limitations, pressure traces approximated ± 30 seconds of crew times.

RESULTS

Seven monitoring agencies submitted sensor data for 110 sites from the 2003 regional monitoring survey. Of these, 99 had acceptable quality control for further analysis. The 11 sites were rejected due to anomalous pressure readings and inconsistencies with field crew derived data. Trawl depths ranged from 10 to 463 m (Table 1). Approximately 36% of the sites were from depths less than 50m and roughly 14% of the sites were at depths greater than 150m.

Pressure traces showed several important trawling features (Figure 1). As an example, one 300 m trawl clearly showed two decent scenarios. The first followed net over while the wire was let out (Fig 1A). The second followed the initiation of trawl time deckside, but before the net contacted the bottom (Fig 1B). The second descent rate can be expressed as a multiplication factor of the first descent rate (1A/1B). There were also two time lags; the time it took the net to touch bottom at start of trawl and time it took for the net to come off the bottom during retrieval.

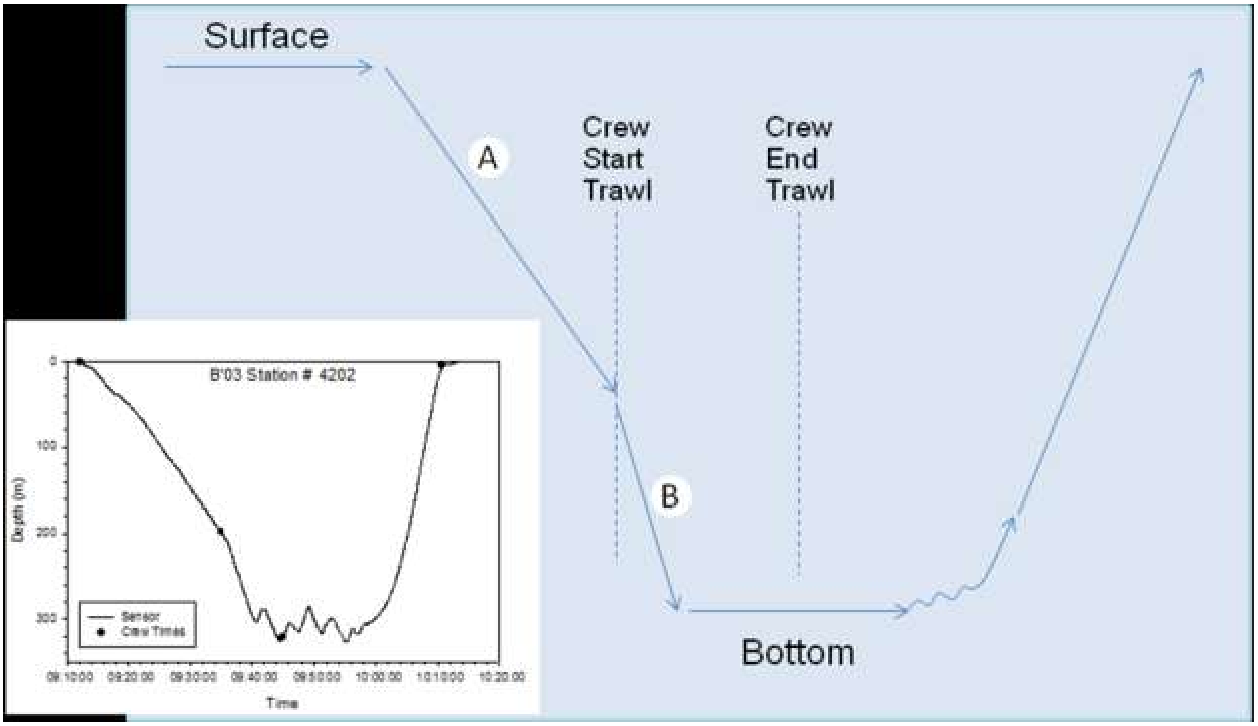

Figure 1. A diagram showing an idealized deep water trawl using a standard method based on a 10 minute tow. Segments A and B highlight two different descent rates. The inset shows a pressure trace at one of the sites during the study. Circles show field crew activities at four points in time: net over, start trawl, end trawl, and net on deck. Site had uneven bathymetry, common in many areas.

Table 1. Study data presented within depth bins to characterize the different trawling components.

Depth Range	# Trawls	A Decent Rate (m/min)	A Decent Rate Range	B Factor Change Rate	B Factor Change Range	Lag Time To Bot (min)	Lag To Bot Range	Lag Time Off (min)	Lag Off Bot Range	Avg Average Sensor Bot Time
10.1 – 25	8	4.2	2.3 - 7.7	+2.7	1.7 - 4.2	-0.3	-2.4 - +1.0	1.4	+0.7 - +3.8	11.8
25.1 – 50	28	5.7	2.8 - 9.8	+2.2	0.9 - 3.2	-0.3	-3.3 - +1.9	2.1	-2.9 - +6.4	12.9
50.1 - 100	35	9.0	5.6 – 16.3	+1.8	0.8 - 4.9	-0.5	-4.3 - +2.8	2.5	-2.5 - +5.1	13.4
100.1 - 150	10	9.8	6.7 – 16.8	+1.4	0.9 - 1.8	-0.4	-7.7 - +3.7	3.5	+1.6 - +6.0	14.0
150.1 - 200	6	12.0	8.9 – 16.6	+1.4	1.1 - 1.6	0.4	-1.5 - +3.0	5.2	+0.9 - +18.0	15.6
>200	8	12.3	8.6 – 20.9	+1.4	0.5 - 2.2	2.6	-2.8 - +7.4	7.8	+3.5 - +15.2	14.5

Components of the different trawl phases varied among depth (Table 1). The average descent rate for the study was 8.2 m/min, ranging from 2.3 to 20.9 m/min. The average multiplication factor between the first and second descent rates was 1.9, ranging from 0.5 to 4.9. The lag to bottom time ranged from -7.7 to 7.4 min. Negative lag times indicated that the net reached the sea floor before the wire scope was fully deployed from the boat. At depths greater than 150 m, the average lag time increased with depth. The average lag time off the bottom during net retrieval also increased with depth. Lag time off bottom ranged from -2.9 to 18 min.

Average bottom times generally increased with depth, but this correlation was not statistically significant (Table 1). Average bottom times ranged from 11 to 15 min among the different depth ranges. The differences in bottom times were generally not attributable to large differences in scope (Figure 2). Rather, differences in bottom time were likely due to inconsistencies in required scope, compounded by unknown estimates for required descent, on-bottom, and deck trawl times.

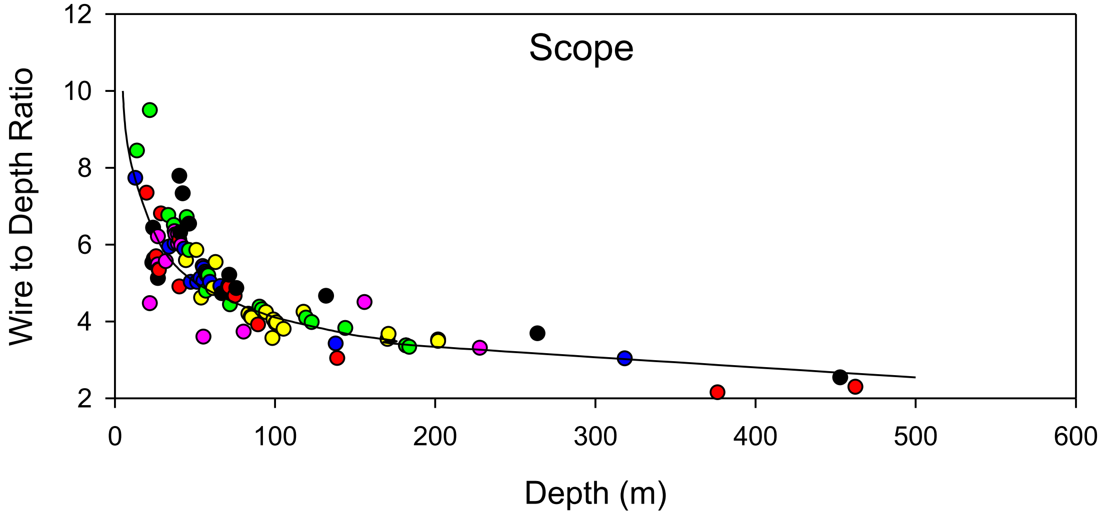

Figure 2. Ten minute trawls showing agency scope relationship during the study compared to the recommendation values within the standard trawling protocol.

To achieve the ultimate goal of a near 10 minute bottom time, trawl parameters were optimized by creating models based on the study results. These parameters included scope, wire lengths, lag time off bottom, and deck time. The scope (ratio of wire:depth) was a non-linear relationship based on the study data (Figure 2) described by the power function in equation 1

$$y = z\,x^{s} \qquad \text{(eq 1)}$$

Where y = scope ratio;

z = 16.139219;

x = target station depth; and

s = -0.297449384.

From scope estimates, wire lengths were transformed using field crew average winch rates and descent rates to obtain the expected wire depth when the crew starts a trawl. The lag time to bottom was derived by equation 2:

$$l = \frac{(x-d)}{(rf)} \qquad \text{(eq 2)}$$

Where l = lag time to bottom;

x = target depth;

d = wire depth;

r = descent rate; and

f = 2nd descent rate factor.

The lag off the bottom time was estimated using a regression formula based on the study results in equation 3:.

$$o = a + bx \qquad \text{(eq 3)}$$

Where o = lag time off bottom;

a = 1.4903252151;

b = 0.0141874591; and

x = target depth.

The result are estimated deck times necessary to produce a 10 minute bottom time, which varies depending on the lag time to and off the bottom (Table 2).

Table 2. Projected deck times to achieve a 10-minute bottom time based on pressure data submitted during the 2003 Southern California Bight Regional Survey. Wire depths greater than station depths mean the net was expected to be on the bottom before the winch let out the appropriate wire length.

Station Depth (m)	Depth/Wire Scope[1]	Wire (m)	Winch[2] Time (min)	Wire[3] Depth (m)	Minutes To Bot Lag[4]	Minutes Off Bot Lag[5]	10 Min Trawl Est Deck Time (min)
5	10.0	50	1.21	10.05	-0.38	1.56	8.06
10	8.1	81	1.98	16.36	-0.48	1.63	7.89
20	6.6	132	3.22	26.62	-0.50	1.77	7.72
30	5.9	176	4.28	35.39	-0.41	1.92	7.67
40	5.4	215	5.24	43.32	-0.25	2.06	7.69
50	5.0	252	6.12	50.67	-0.05	2.20	7.75
60	4.8	286	6.96	57.60	0.18	2.34	7.84
70	4.6	319	7.76	64.19	0.44	2.48	7.96
80	4.4	351	8.52	70.50	0.72	2.63	8.10
90	4.2	381	9.25	76.58	1.02	2.77	8.25
100	4.1	410	9.97	82.47	1.33	2.91	8.42
120	3.9	466	11.33	93.74	1.99	3.19	8.80
140	3.7	520	12.62	104.46	2.70	3.48	9.22
160	3.6	571	13.86	114.73	3.44	3.76	9.68
180	3.4	620	15.06	124.63	4.20	4.04	10.16
200	3.3	668	16.22	134.21	4.99	4.33	10.67
220	3.2	714	17.34	143.50	5.81	4.61	11.19
240	3.2	759	18.43	152.55	6.64	4.90	11.74
260	3.1	803	19.50	161.37	7.49	5.18	12.31
280	3.0	846	20.54	169.99	8.35	5.46	12.89
300	3.0	888	21.56	178.44	9.23	5.75	13.48
320	2.9	929	22.56	186.71	10.12	6.03	14.09
340	2.9	969	23.55	194.84	11.02	6.31	14.70
360	2.8	1009	24.51	202.82	11.93	6.60	15.33
380	2.8	1048	25.46	210.67	12.85	6.88	15.97
400	2.7	1086	26.39	218.40	13.78	7.17	16.62
420	2.7	1124	27.31	226.02	14.72	7.45	17.27
440	2.6	1162	28.22	233.53	15.67	7.73	17.94
460	2.6	1198	29.12	240.94	16.63	8.02	18.61
480	2.6	1235	30.00	248.25	17.59	8.30	19.29
500	2.5	1271	30.87	255.47	18.56	8.58	19.97

[1] Power function was 16.139219 * (Station Depth $^{-0.297449384}$) based on method protocol.

[2] Average agency winch rate was 41.16 m/min.

[3] Average descent rate was 8.3 m/min. Average lag on bottom decent rate changed +1.6 times.

[4] Used: (Station Depth – Wire Depth) / (Avg Descent Rate * Avg Change Rate Factor).

[5] Used: regression: 1.4903252151 + (0.0141874591*Station Depth)) based on Lag Off vs. Depth data.

Using the model to assess field crew performance (expected vs. actual), the study results were mixed from different organizations applying the same ship-based method in a 2008 survey (Figure 3). Experts agreed during pre-study meetings that the optimal window should be between 8 – 15 minute bottom times. The model line predicts the resulting bottom times expected if crews followed the guidelines in the survey procedures. During the 2008 regional survey, crews with trawl sites deeper than 200 m were specifically requested to adjust bottom net times to the optimal window. The graph shows crew bottom time performance departing from expected, even below 200 m depth. Overall, 58% of the trawls were within the optimal time bracket. Sixty-nine percent of the trawls shallower than 250 m were within the optimal time bracket. Bottom time departures trended toward higher than expected net contact with the sea floor. Deviations away from the optimal window were the result of different descent rates (i.e., boat speed, winch rate, wire thickness), lag time off the bottom, field crew errors, and vessels not maintaining speed upon net retrieval. The field crews need to minimize the scatter away from the optimal time bracket. Analysts should use caution when selecting catch-per-unit-effort (CPUE) units for trawl data.

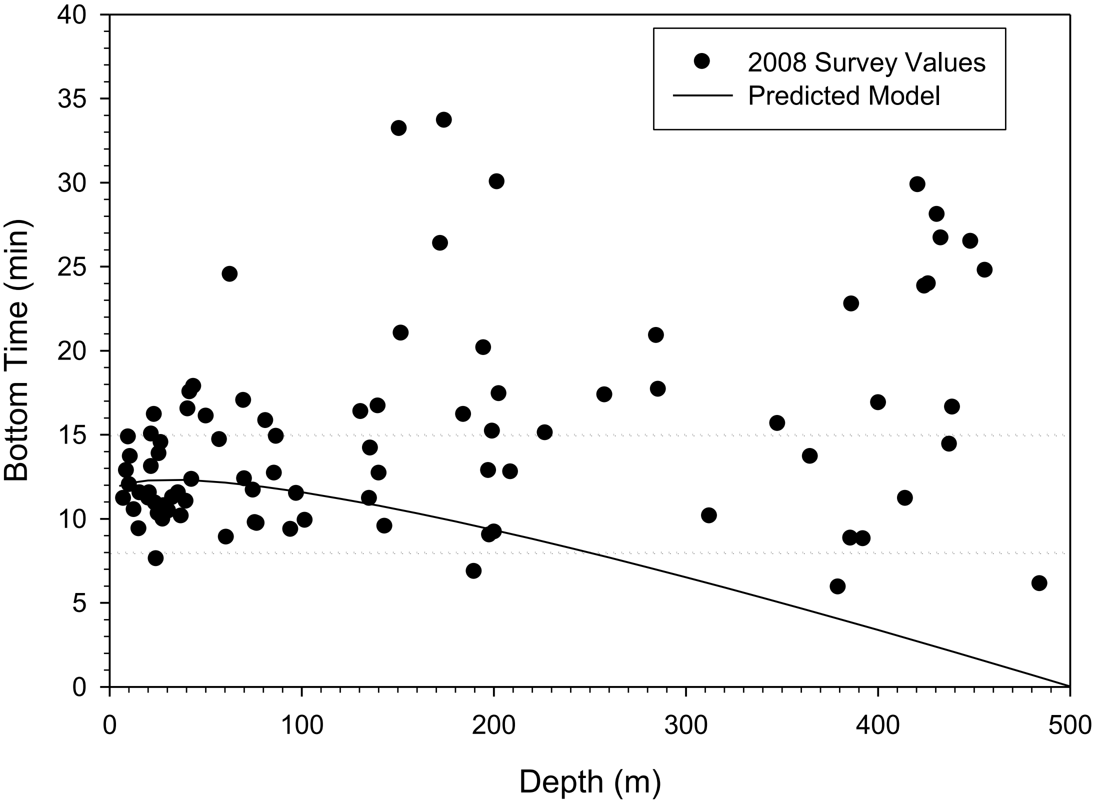

Figure 3. Bottom times from the 2008 Southern California Bight Regional Monitoring Survey (89 sites). The 2003 model predicts the results of the method used in the survey. Some crews deliberately adjusted times to achieve a 8-15 minute quality assurance criteria.

DISCUSSION

The new technology evaluated in this study has, for the first time, enabled accurate assessments of on-bottom times for scientific trawling. For example, the dual decent rate phenomenon for trawl nets, which were assumed previously, have now been quantified and linked directly to field crew activities deckside. This study has helped establish that nets touch bottom much faster than previously thought in shallow water. Conversely, this study helped establish that it takes much longer for nets to touch bottom in deep water, especially deeper than typically sampled in the study area (ca. > 250m). The new technology also helped measure lag times in net response. Never before has the lag times off bottom for scientific trawling been quantified with the accuracy seen in this study.

One advantage of the new technology is the ability to improve sampling standardization. Based on the study results, optimized trawl parameters were modeled to improve the success of achieving standardized bottom times. While a standardized trawl is given at 10 minutes, acceptable bottom times currently range from 8-15 min. Based on the hundreds of man-years experience of field crews used in this study, bottom times often fell within acceptable bounds for depths (< 150 m) routinely monitored. Where the value of this study will be particularly useful is for depths not normally encountered, especially deeper than 200 m where trawl failures are costly mistakes. At depths of 480m, a single trawl may take over an hour, not including post-trawl work-up of the sample.

There were several advantages and limitations of the new technology for scientific trawling. Perhaps the most coveted advantage is the ability to evaluate trawl bottom times immediately after trawl retrieval. Easily downloadable data and instant graphics helped offset the challenge of increased effort for the supplementary information and increased quality control. However, fairly frequent failure of the pressure sensors was also observed. Approximately 10% of the trawls during this study had sensors that failed or produced poor data. This may have been a manufacturing defect and not the technology itself. Hopefully, improvements in sensor technology and manufacturing will not only reduce the frequency of failures, but also the cost.

Standardized 10 minute trawls will continue to be an important component of ocean monitoring. The public's quest for answers about the health of the fish community will undoubtedly increase over time as environmental managers take actions to protect our ocean environment. In southern California, monitoring questions associated with water quality regulation will not cease, especially as public utilities spend up to $31 million to monitor and improve treatment prior to discharge (Bight 2003 Steering Committee 2007). In addition, resource management actions such as marine protected areas only increase the public's thirst for answers to the status (and improvement) of fish communities (see http://www.dfg.ca.gov/mlpa/). The standardization in trawling methods partly developed in this study will not only improve comparisons over time in existing habitats, but also enhance comparisons across different habitats. The result should be an overall increase in the power to detect changes in fish communities because the variation associated with sampling can be reduced.

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