

QUALITY IMPROVEMENT STORY

2nd SLICE TEAM

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REASON FOR IMPROVEMENT

HISTORY

TESTING OF ALICE & VACUM SYSTEMS 1982-1983

EVALUATION OF KRAFTWERK UNION SYSTEM 1984-1985

INSTALLATION OF WESMAR SINGLE SOUNDOME SYSTEM, CONSTRUCTION OF CANAL CROSSING & BARRIER NET 1986-1987

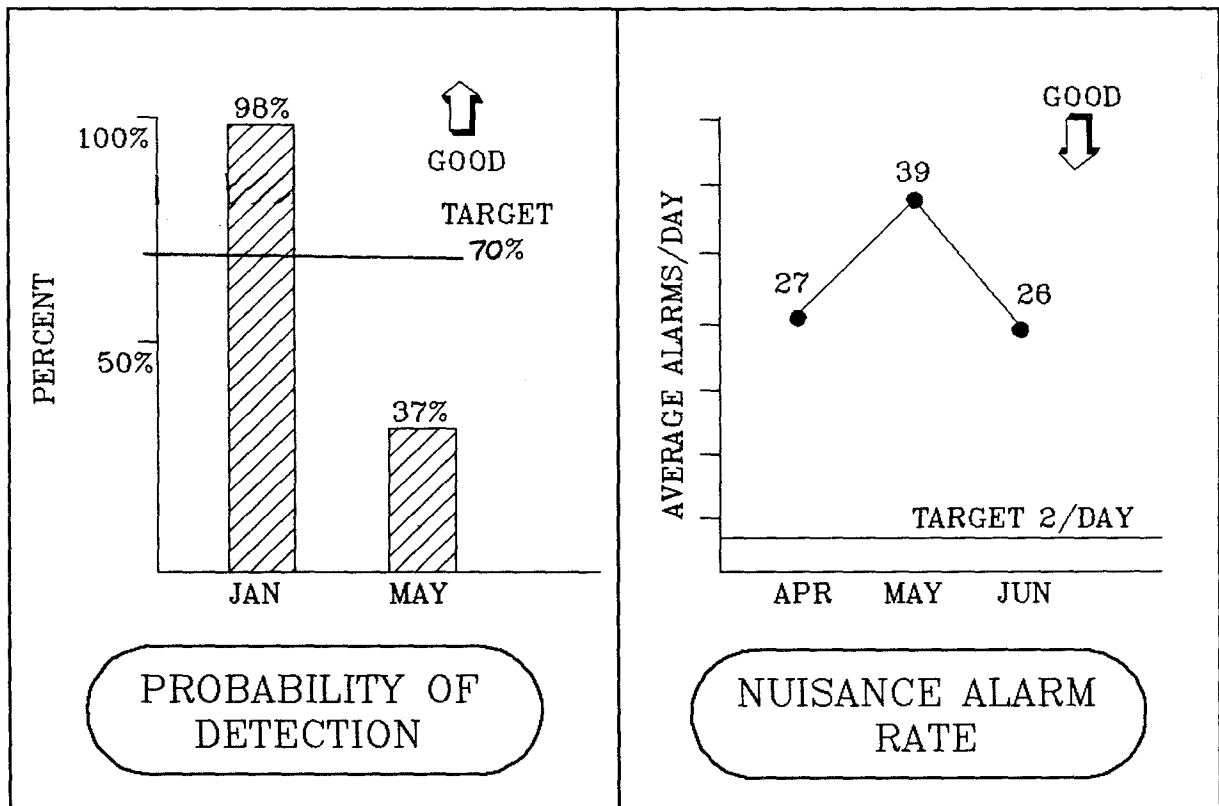
ENHANCEMENT OF WESMAR SYSTEM TO DUAL SOUNDOME (SLICE TEAM) 1988

TESTING OF DUAL SYSTEM (PD GREATER THAN 90%) JAN 1989

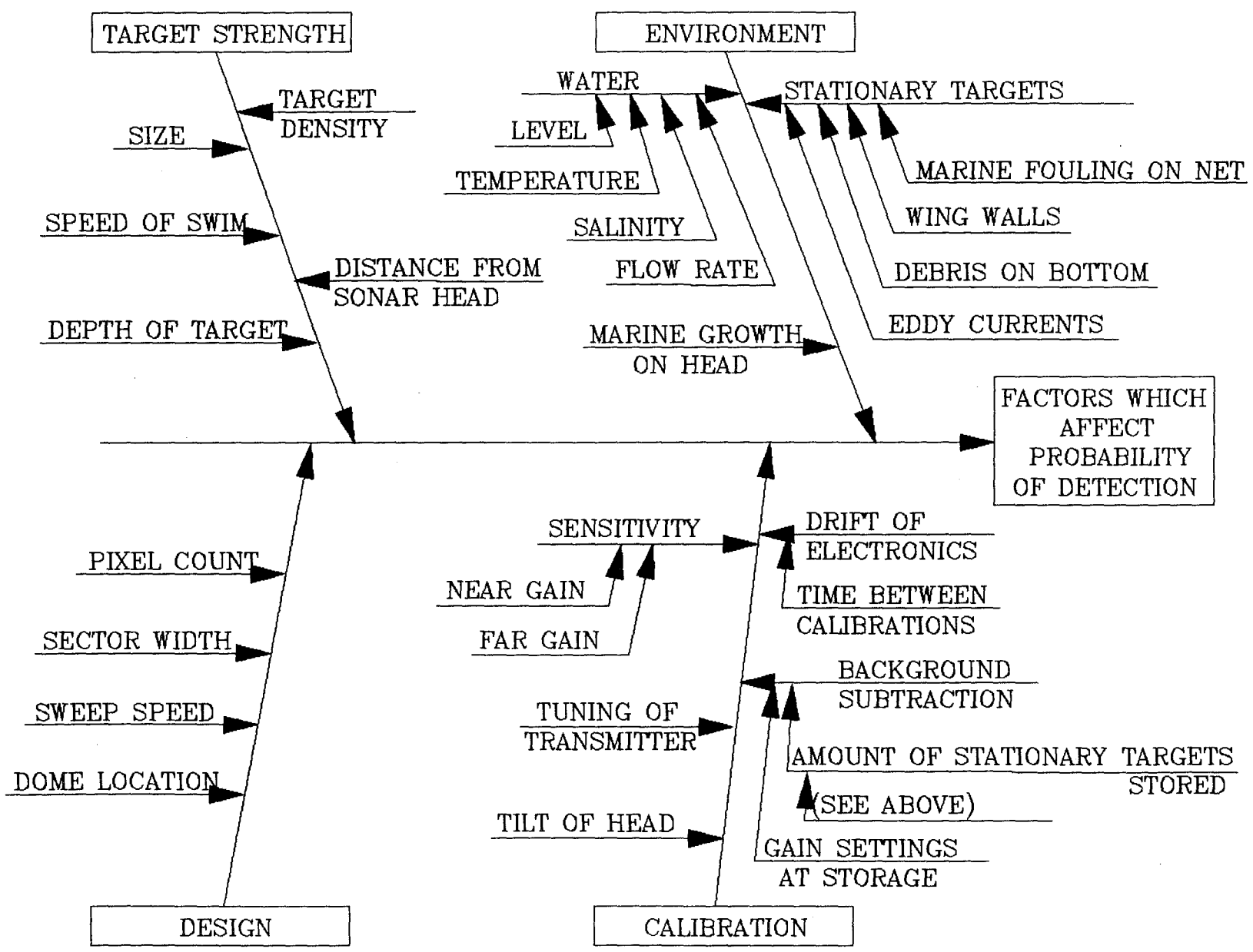
THEME

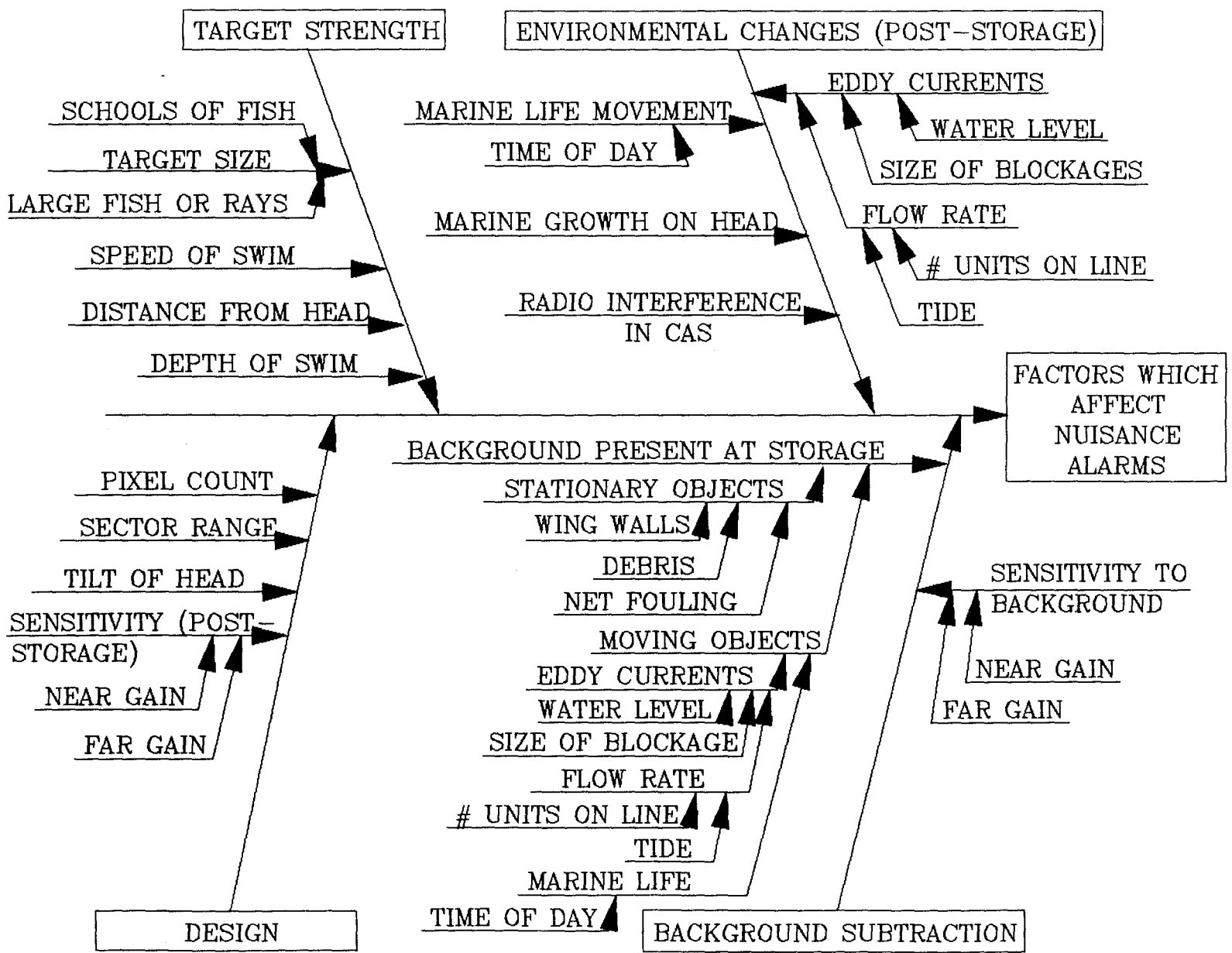
RECENT TESTS (APRIL TO JUNE, 1989) SHOW A HIGH NUISANCE ALARM RATE AND LOWER PROBABILITY OF DETECTION. PD MUST BE MAXIMIZED TO SATISFY REGULATORY REQUIREMENTS. NUISANCE ALARMS MUST BE MINIMIZED TO PREVENT CONTINUOUS COMPENSATORY GUARD POSTING.

CURRENT SITUATION



PROBLEM STATEMENT:
THE UIDS (UNDERWATER INTRUSION DETECTION SYSTEM) IS UNABLE TO MAINTAIN A HIGH PROBABILITY OF DETECTION AND A LOW NUISANCE ALARM RATE.





ANALYSIS

DESIGN OF EXPERIMENTS

All factors which affect probability of detection are identified and evaluated.

INPUT VARIABLE	ESTIMATED EFFECT	TEST	(1) CONTROL	RANDOMIZED IN TESTING
SPEED OF SWIM	M		Y	
DEPTH OF TARGET	M			Y
TARGET SIZE	H			Y
DISTANCE FROM HEAD	L			Y
PIXEL COUNT	H	Y		
SECTOR WIDTH	L		Y	
SWEEP SPEED	M		Y	
DOME LOCATION	H		Y	
WATER (LEVEL, TEMP, FLOW, ETC)	L			Y
GROWTH ON HEAD	L		Y	
SEAWEED	L			Y
STATIONARY TARGETS	M		Y	
SENSITIVITY (NEAR & FAR GAIN)	H	Y		
TUNING OF XMTR	L		Y	
TILT OF HEAD	L		Y	
ELECTRONICS DRIFT	H			Y
BACKGROUND SUBTRACTION	H	Y		

(1) TESTING SPECIFICATIONS & PROCEDURES WERE DESIGNED TO INSURE THAT THESE FACTORS WOULD BE CONTROLLED DURING TESTING.

ANALYSIS

DESIGN OF EXPERIMENTS

All factors which affect nuisance alarm rate are identified and evaluated.

INPUT VARIABLE	ESTIMATED EFFECT	TEST	CONTROL	RANDOMIZED IN TESTING
FISH SIZE	H			Y
DEPTH OF TARGET	L			Y
SPEED OF SWIM	L			Y
PIXEL COUNT	H	Y		
SECTOR RANGE	L		Y	
PRESENCE OF MARINE LIFE	H		Y (1)	
BACKGROUND CHANGES (DEBRIS, EDDY & ROCKS)	M			Y
GROWTH ON HEAD	L		Y	
SENSITIVITY	H	Y		
TILT OF HEAD	L		Y	
BACKGROUND SUBTRACTION	L	Y		
(1) NUISANCE TESTING WILL BE PERFORMED AND RECORDED.				

ANALYSIS

DESIGN OF EXPERIMENTS FOR ST. LUCIE UNDERWATER INTRUSION DETECTION SYSTEM

STEP I: UTILIZATION OF DESIGN OF EXPERIMENTS APPROACH

All process inputs were identified and classified:

MAXIMIZE: (Large impact factors of interest)

- NEAR GAIN (NG)
 - FAR GAIN (FG)
 - PIXEL COUNT (PC)
 - BACKGROUND STORAGE (BG)
- } Affect sensitivity

MINIMIZE: (Small impact factors)

ENVIRONMENTAL FACTORS
(not controllable)

- WATER LEVEL
- WATER TEMPERATURE
- SALINITY
- WEATHER

CONTROL: (Large impact factors of no
interest)

- TILT OF THE SONAR
- SPEED AND SIZE OF THE DIVER
- LOCATION

ANALYSIS

STEP II: THE UIDS FULL FACTORIAL EXPERIMENT

Each of the maximized factors were assigned extreme maximum and minimum values:

VARIABLE SETTING	EXPERIMENT NUMBER															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NG-MAX	X		X		X		X		X		X		X		X	
NG-MIN		X		X		X		X		X		X		X		X
FG-MAX	X	X			X	X			X	X			X	X		
FG-MIN			X	X			X	X			X	X			X	X
PC-MAX	X	X	X	X					X	X	X	X				
PC-MIN					X	X	X	X					X	X	X	X
BG-MAX	X	X	X	X	X	X	X	X								
BG-MIN									X	X	X	X	X	X	X	X

The sixteen experiments were performed randomly and each experiment consisted of 15 swims through all areas of the canal for a total of 240 swims for the sixteen experiments.

STEP III: RANDOMIZATION

The tests were duplicated to determine the existence of interaction among the factors for a total of 480 swims.

ANALYSIS

STEP IV: ANALYSIS OF UIDS FULL FACTORIAL EXPERIMENT

The logistic regression performed by computer on the results of the experiment determined the significance of each of the maximized factors as follows:

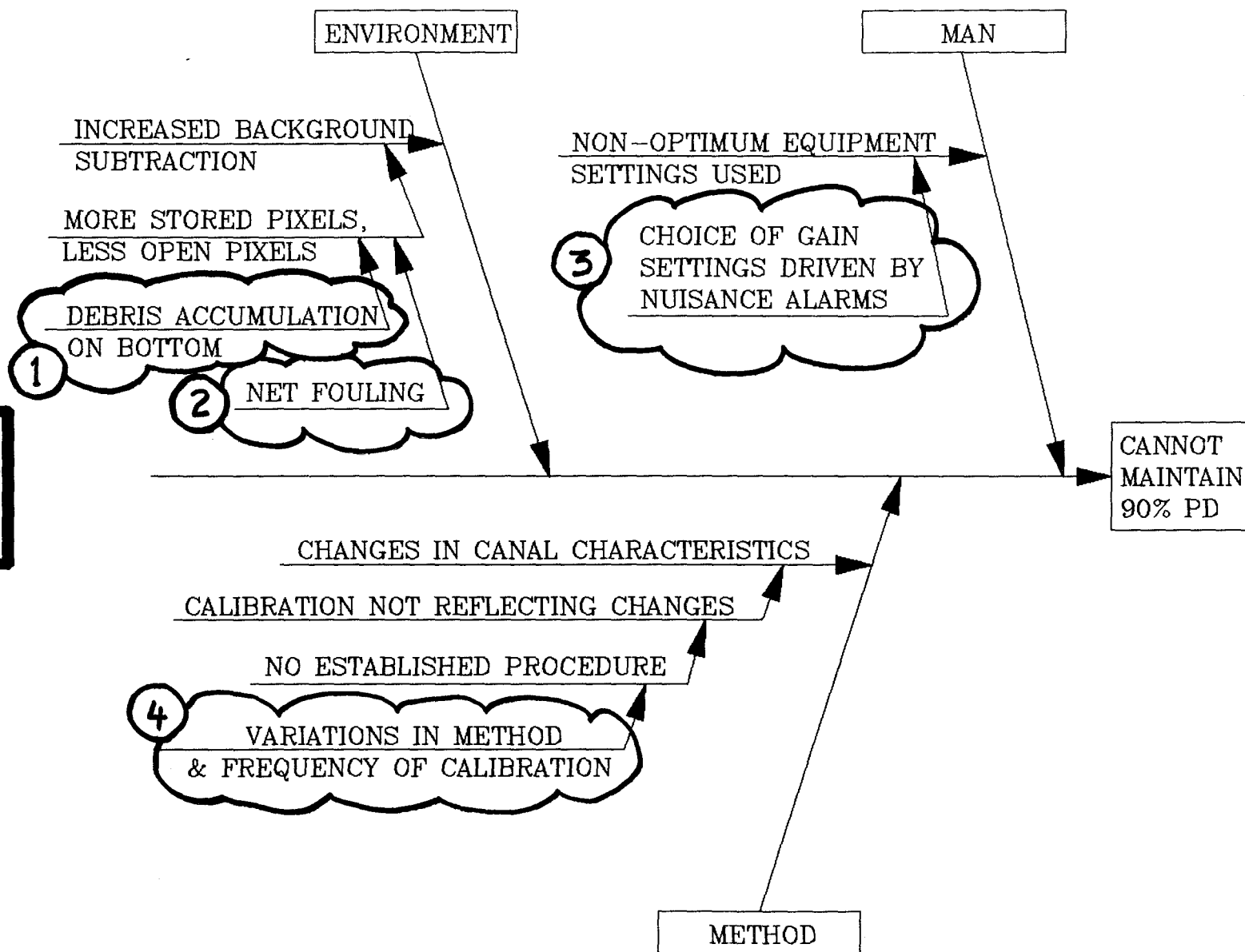
STATISTICALLY SIGNIFICANT

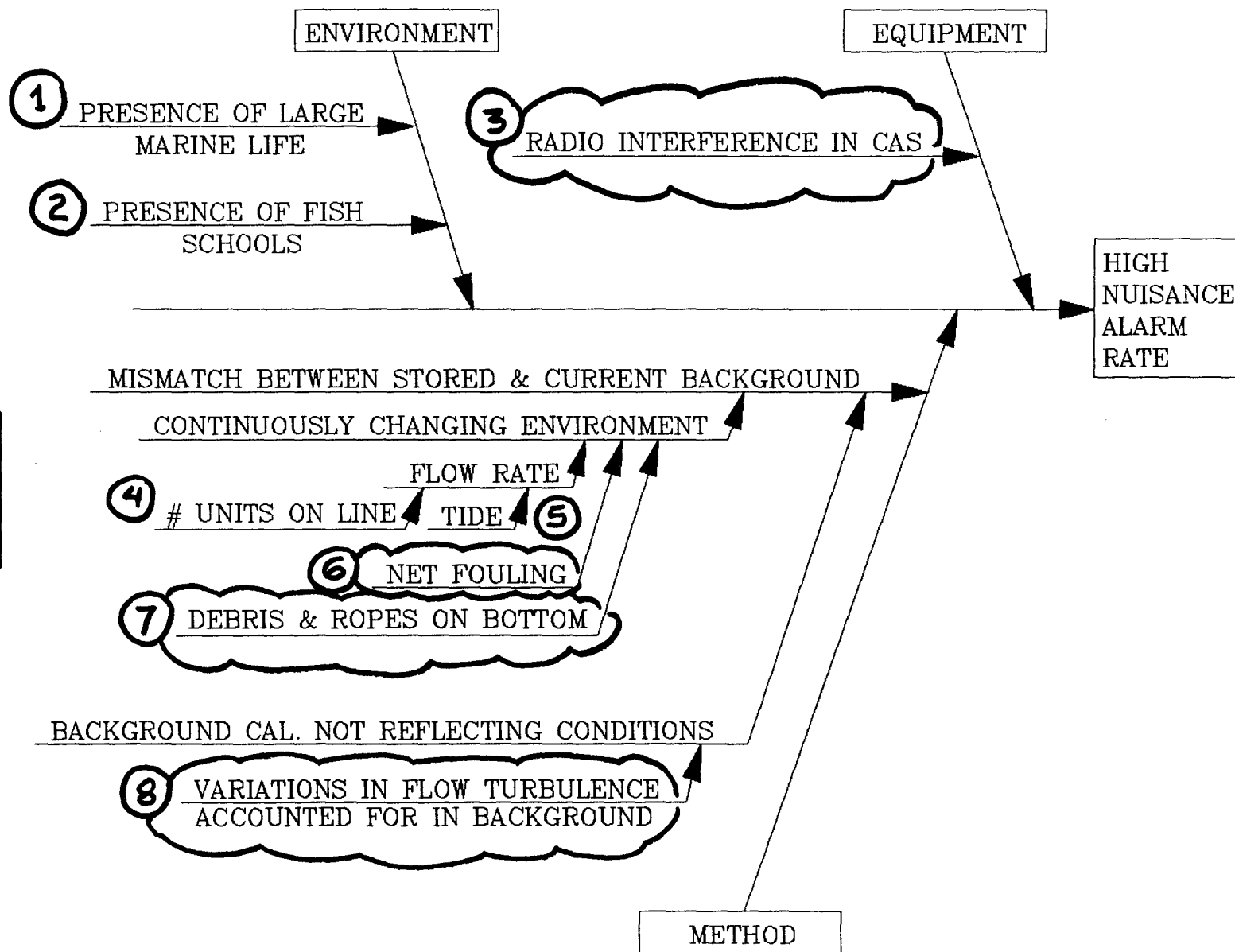
- NEAR GAIN
- PIXEL COUNT

CONTROLLED FACTOR (NO SIGNIFICANCE)

- FAR GAIN
- BACKGROUND STORAGE

The presence of interaction (dependence) was not detected.





ROOT CAUSE EVALUATION - PROBABILITY OF DETECTION

POTENTIAL ROOT CAUSE	WITHIN TEAM'S CONTROL ?	ROOT CAUSE SYMPTOM ETC.	VERIFICATION PROCESS
1. DEBRIS ACCUMULATION ON CANAL BOTTOM	YES	ROOT CAUSE	PHYSICAL EXAMINATION IN CONJUNCTION WITH BEFORE & AFTER STATIC TESTING OF EFFECTIVENESS.
2. NET FOULING	YES	ROOT CAUSE	PHYSICAL EXAMINATION IN CONJUNCTION WITH BEFORE & AFTER STATIC TESTING OF EFFECTIVENESS.
3. CHOICE OF GAIN SETTINGS DRIVEN BY NUISANCE ALARMS	YES	ROOT CAUSE	LOGISTIC REGRESSION ANALYSIS OF TESTING RESULTS SHOW HIGH PD STILL ATTAINABLE, LOWER PD TIED TO LOWERING NUISANCE ALARM RATE.
4. VARIATIONS IN METHOD	YES	ROOT CAUSE	EXAMINATION OF LOGS & RECORDS SHOW VARIATIONS. STANDARDIZATION OF CALIBRA- TION METHODS IN TEST PROCEDURE SHOWS IMPROVED RESULTS.

ROOT CAUSE EVALUATION – NUISANCE ALARMS			
POTENTIAL ROOT CAUSE	WITHIN TEAM'S CONTROL ?	ROOT CAUSE SYMPTOM ETC.	VERIFICATION PROCESS
1. PRESENCE OF LARGE MARINE LIFE	NO *	ROOT CAUSE	DIVER & GUARD DIRECT OBSERVATION. ALSO PATTERNS SEEN DURING OVERNIGHT RECORDINGS.
2. PRESENCE OF FISH SCHOOLS	NO *	ROOT CAUSE	DIVER & GUARD DIRECT OBSERVATION. INCREASE IN NUISANCE ALARMS DURING NIGHTTIME FEEDING ACTIVITY, WHEN SCHOOLING IS COMMON.
3. RADIO INTERFERENCE IN CAS	YES	ROOT CAUSE	PHENOMENON OBSERVED DURING TESTING.
4. NO. UNITS ON LINE	NO	-----	-----
5. TIDAL ACTION	NO	-----	-----
6. NET FOULING	YES	ROOT CAUSE	PHYSICAL EXAMINATION IN CONJUNCTION WITH BEFORE & AFTER TESTING OF CONTRIBUTION.
7. DEBRIS & ROPES ON BOTTOM	YES	ROOT CAUSE	PHYSICAL EXAMINATION IN CONJUNCTION WITH BEFORE & AFTER TESTING OF CONTRIBUTION.
8. VARIATIONS IN FLOW TURBULENCE ACCOUNTED FOR IN BACKGROUND	YES	ROOT CAUSE	EXAMINATION OF LOGS & RECORDS SHOW VARIATIONS. STANDARDIZATION DURING STATIC ALARM TESTING SHOWS CONTRIBUTION.

*NOT FEASIBLE DUE TO RISK TO UNITS & FISH GROWTH RATE; NOT A VIABLE PERMANENT SOLUTION.

PROBLEM
CANNOT
MAINTAIN
90% PD

ROOT CAUSE	COUNTERMEASURE	PRACTICAL METHOD	EFFECT.	FEAS.	OVERALL	ACTION ?
DEBRIS ACCU- MULATION ON CANAL BOTTOM	REMOVE ACCUMULATED DEBRIS.	DIVERS REMOVE DEBRIS SEEN BY SONAR	3	4	12	YES
NET FOULING	REMOVE MARINE GROWTH ON NET	DIVERS REMOVE SEAWEED, ETC. FROM NET PROTECTION	3	4	12	YES
		ESTABLISH PERIODIC CLEANING	3	3	9	YES
CHOICE OF GAIN SETTINGS DRIVEN BY NUISANCE ALARMS.	OPTIMIZE PD & NUISANCE ALARM RATE, TOGETHER	TEST VARYING NEAR GAIN SETTING TO OPTIMIZE PD & NUISANCE ALARMS (CON- FIRMATION TESTS)	5	4	20	YES
VARIATIONS IN METHOD & FREQUENCY OF CALIBRATION	SELECT A SINGLE APPROPRIATE METHOD & SCHEDULE	STANDARDIZE METHODOLOGY IN A PROCEDURE	5	5	25	YES
		USE TEST BALL TARGET	5	5	25	YES

COUNTERMEASURES

PROBLEM HIGH NUISANCE ALARM RATE	ROOT CAUSE	COUNTERMEASURE	PRACTICAL METHOD	EFFECT.	FEAS.	OVERALL	ACTION ?
	PRESENCE OF LARGE MARINE LIFE	RESTRICT FISH FROM CZD	INSTALL NETS TO CONTAIN FISH	3	2	6	NO
	PRESENCE OF FISH SCHOOLS						
	RADIO INTER- FERENCE IN CAS	ELIMINATE INTERFERENCE	KEEP DRAWERS IN RACK MOUN- TING TO GET EMI PROTECTION	4	5	20	YES
	NET FOULING	REMOVE MARINE GROWTH ON NET	ESTABLISH PERI- ODIC CLEANING SCHEDULE	4	4	16	YES
	DEBRIS & ROPES ON BOTTOM	REMOVE DEBRIS & ROPES	DIVERS REMOVE DEBRIS SEEN BY SONAR	4	4	16	YES
			PROM IMPROVEMENTS	3	5	15	YES
	VARYING FLOW TURBULENCE IN BACKGROUND	INCREASE BACKGROUND STORAGE CONSISTENCY	STANDARDIZE METHOD IN A PROCEDURE	5	5	25	YES

COUNTERMEASURES

TESTING TO OPTIMIZE COUNTERMEASURES

STEP I: OPTIMIZATION OF UIDS STATISTICALLY SIGNIFICANT FACTORS

A series of tests were conducted for each combination of incremental values through the useful ranges of NEAR GAIN and PIXEL COUNT:

FACTOR & SETTING	PC INCR 1	PC INCR 2
NG-INCR 1	X	X
NG-INCR 2	X	X
NG-INCR 3	X	X
NG-INCR 4	X	X
NG-INCR 5	X	X
NG-INCR 6	X	X

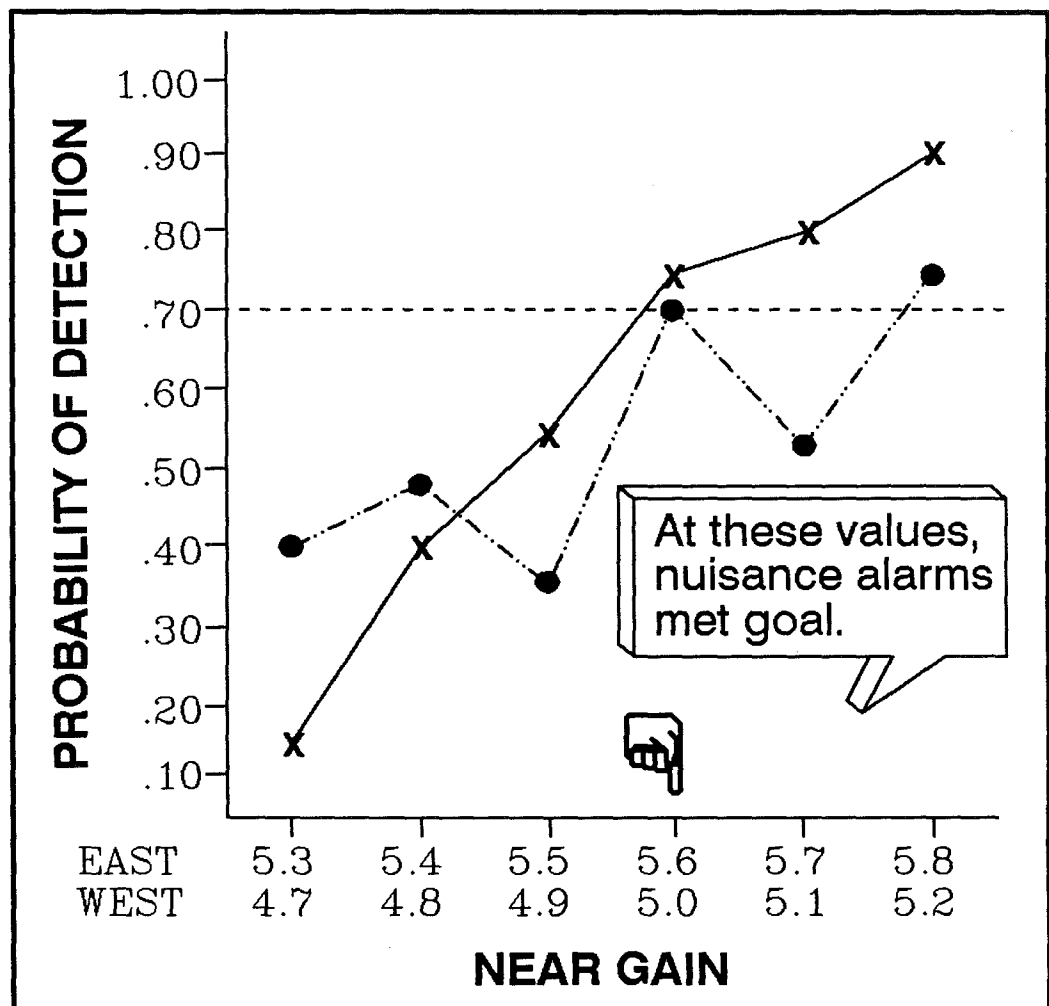
Each of the randomly performed tests consisted of fifteen random swims through the canal.

FAR GAIN and BACKGROUND STORAGE (controlled factors) were fixed at a constant setting.

COUNTERMEASURES

STEP II: DETERMINATION OF UIDS OPTIMAL SETTINGS

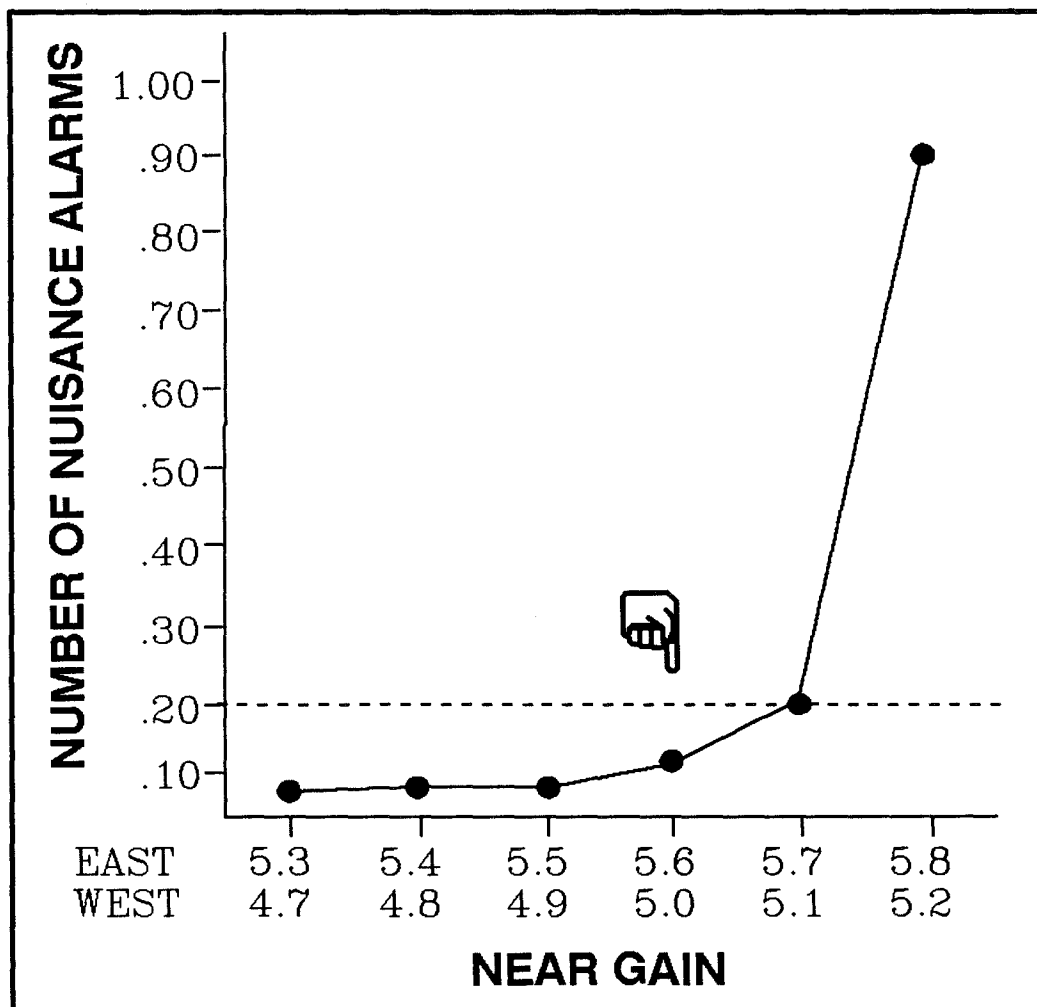
The results of the significant factors were graphed and the optimum settings shown were selected based on improvement over past testing results.



● - 3 x 3 PIXEL COUNT

x - 4 x 3 PIXEL COUNT

COUNTERMEASURES



● - 3 x 3 PIXEL COUNT

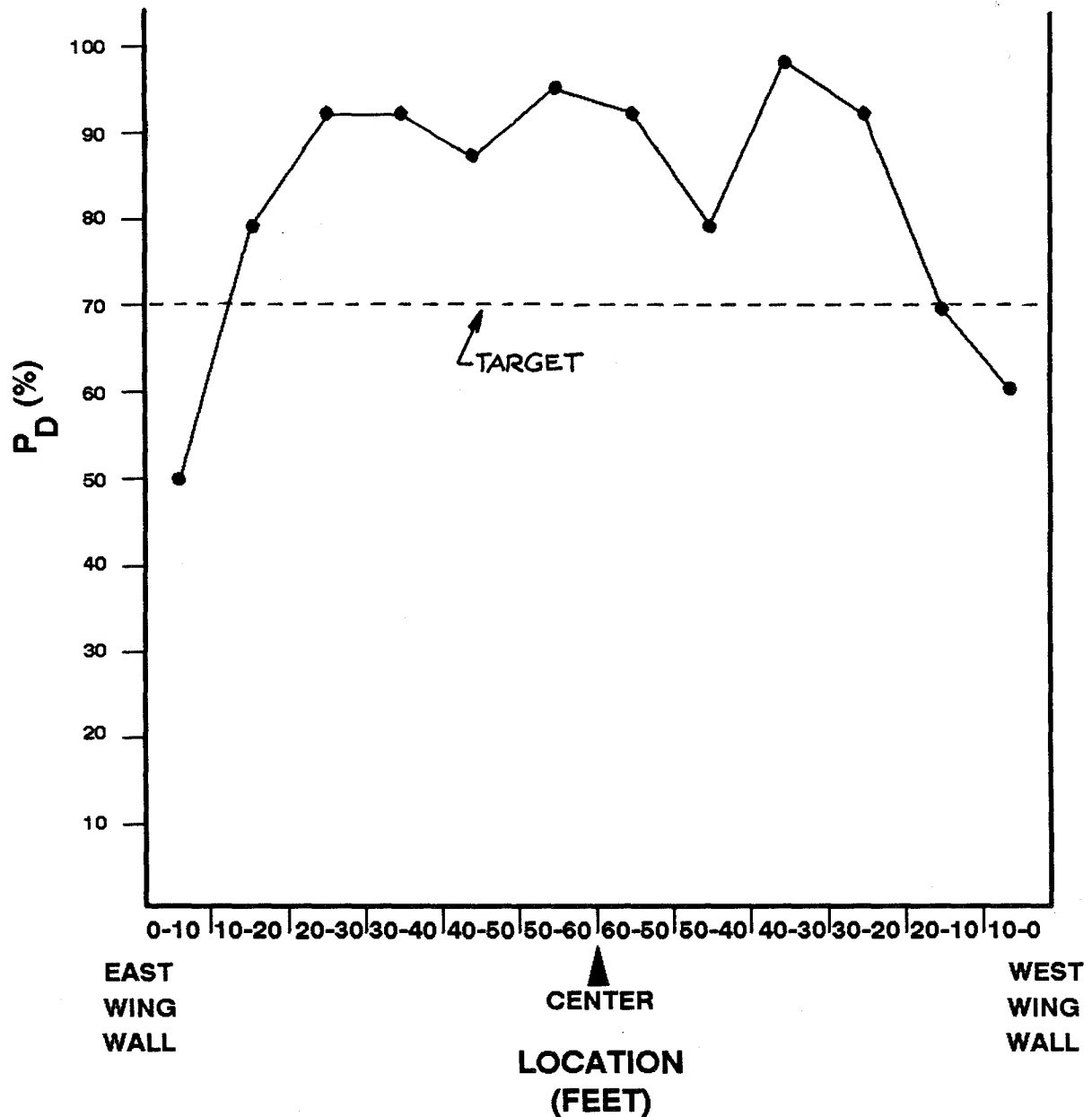


x - 4 x 3 PIXEL COUNT

RESULTS

PROBABILITY OF DETECTION VERSUS LOCATION

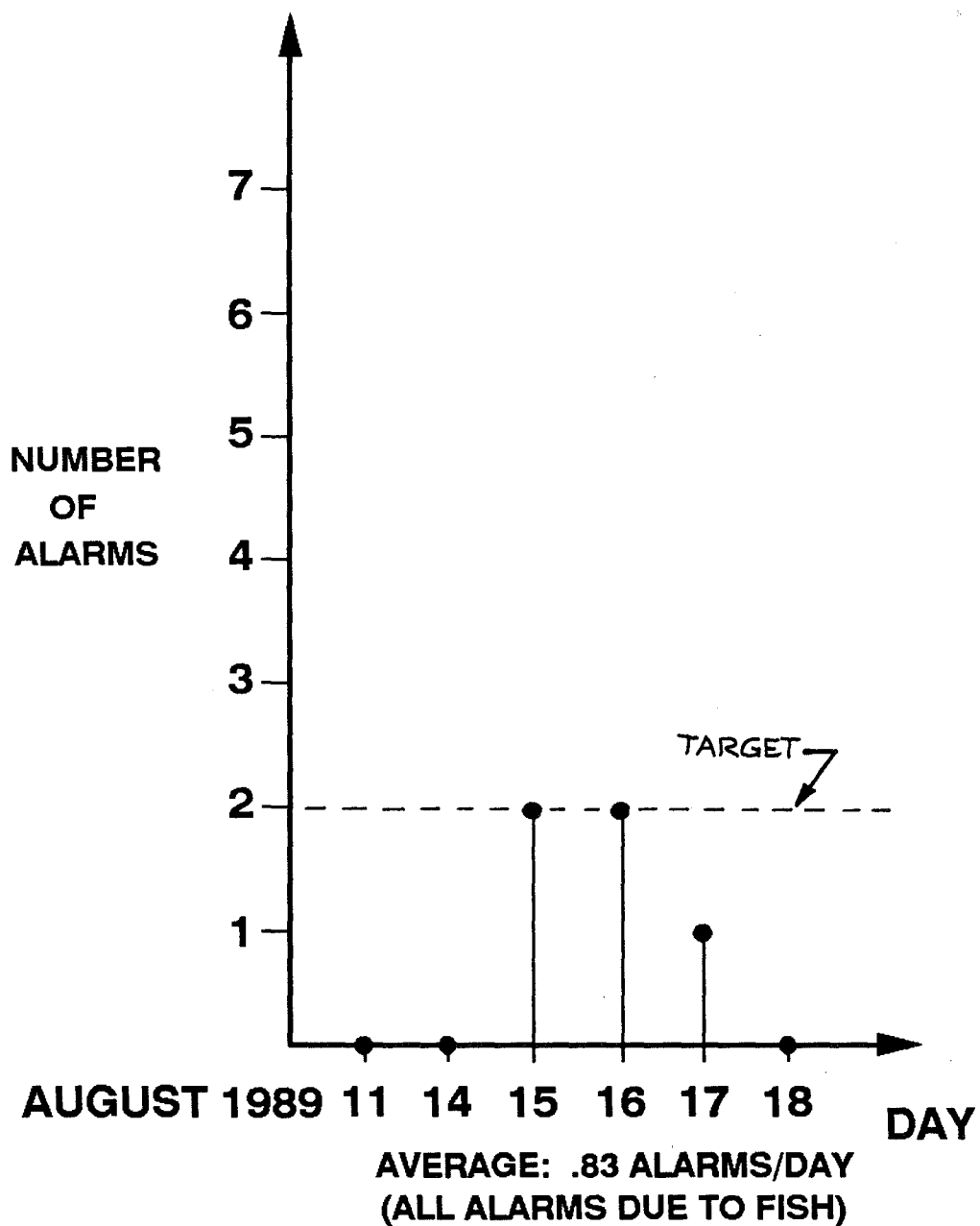
CURRENT CONFIGURATION



RESULTS

NUISANCE ALARMS AND ROOT CAUSES

CURRENT CONFIGURATION



DATE OF TESTS	PROBABILITY OF DETECTION								NUISANCE /FALSE ALARM RATE
	OVERALL (95% CONF.)	CENTER	30 FT FROM EWW	1-20 FT FROM EWW	30 FT FROM WWW	1-20 FT FROM WWW	ALL UNDER- WATER	ALL SURFACE	
January, 1988 (Dual Soundome design concept)	73%	90%	90%	68%	Not Test- ed	Not Tested	90%	50%	High*
August, 1989 (Optimization tests)	75%	91%	92%	62%	92%	62%	87%	64%	0.8/ Zone/ Day

*Alarm rate was monitored during testing only.

STANDARDIZATION

Three measures will be instituted to prevent the problem and its root causes from recurring:

1. Establish periodic canal and net cleaning schedule.
2. Provide a calibration procedure for setting system activities.
3. Provide operator training on the system and calibration procedure.

FUTURE PLANS

- Monitor system performance, by interviews with the customer.
- Continue to investigate ways of improving P_D while maintaining acceptable nuisance alarm levels.
- Provide Maintenance Department with lessons learned on system.

Lessons Learned:

- Power of using design of experiments statistic techniques to analyze a problem.
- Usefulness of having standardized operating procedure for any system, regardless of how simple or complex the system.
- Continued monitoring of a problem resolution is required to stabilize results and ensure success.