COMPARISON OF WATER QUALITY INDICATOR METHODS FOR RECREATIONAL WATER IN SAN DIEGO COUNTY

Beach Water Quality Workgroup Meeting

November 8th and 14th, 2018

COUNTY OF SAN DIEGO
HHSA
HEALTH AND HUMAN SERVICES AGENCY
PUBLIC HEALTH SERVICES

LIVE WELL SAN DIEGO

ACCREDITED HEALTH DEPARTMENT
PHAB
Advancing public health performance
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OBJECTIVE OF STUDY

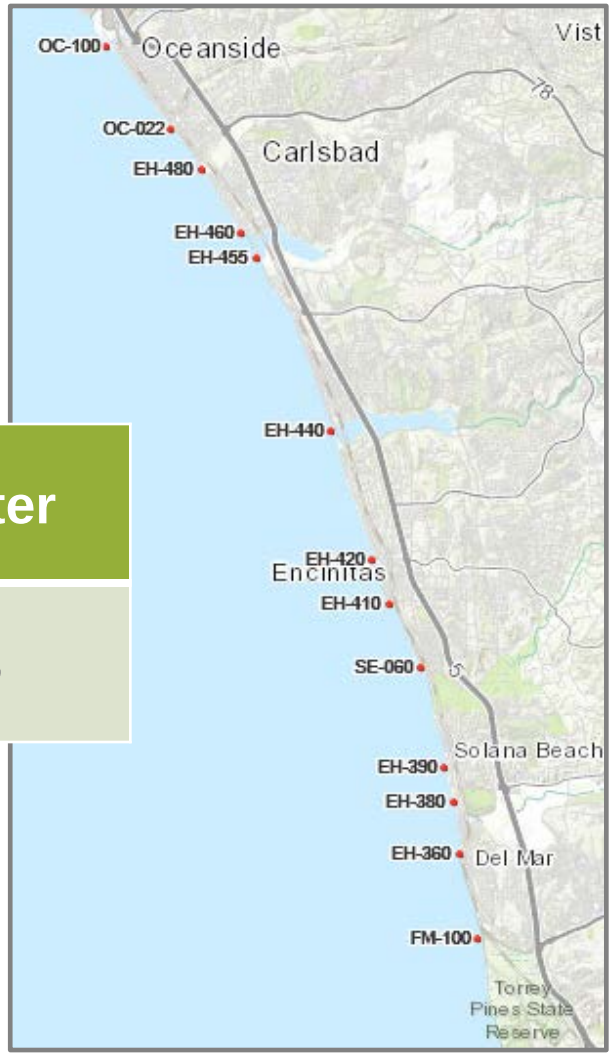
DETERMINE THE BEST METHOD(S) TO USE FOR SAN DIEGO COUNTY BEACHES

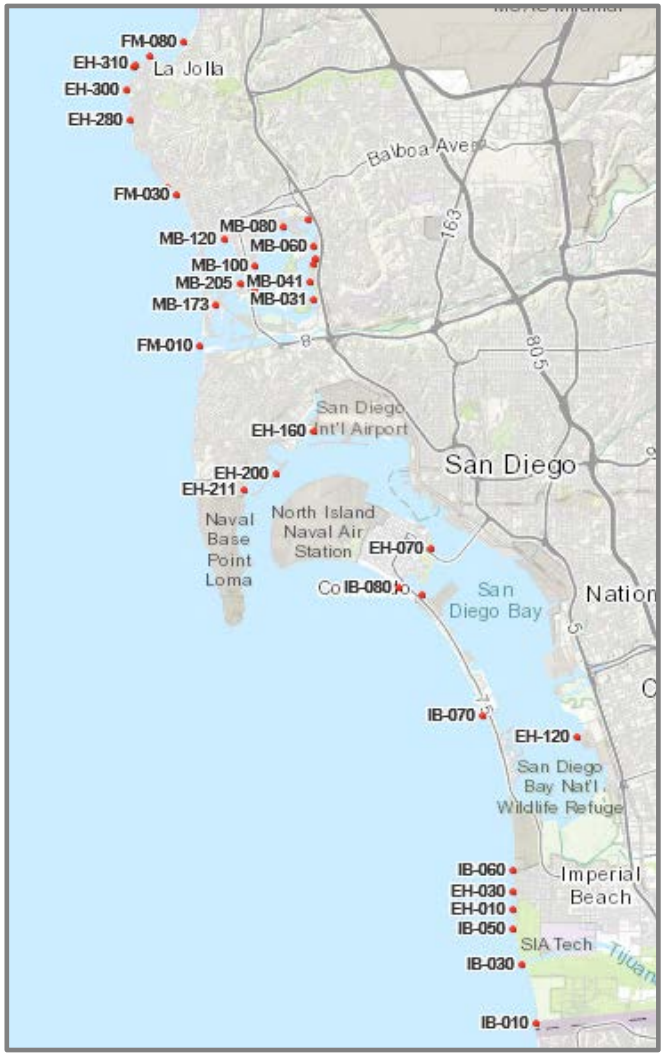
- Goal was to compare three approved methods of water quality indicators across three factors:
  - Time- length of time from receipt of sample to time results are reported (TAT)
  - Cost- staff time and cost of supplies
  - Accuracy- performance and by action level
  - Three assays utilized during the study:
  - Multiple tube fermentation (MTF)- concentration determined by MPN method; currently used in lab, research indicates this assay is labor intensive and has the longest TAT
  - Defined substrate test (DST)- concentration determined by MPN method; research indicates this assay has the fastest TAT but tends to have more false positive results
  - Membrane filtration (MF)- concentration determined by colony counts: research indicates this assay is the most accurate but labor intensive
- Collected and analyzed samples between March 2017 and March 2018

BACKGROUND

SAMPLING LOCATIONS IN SAN DIEGO COUNTY

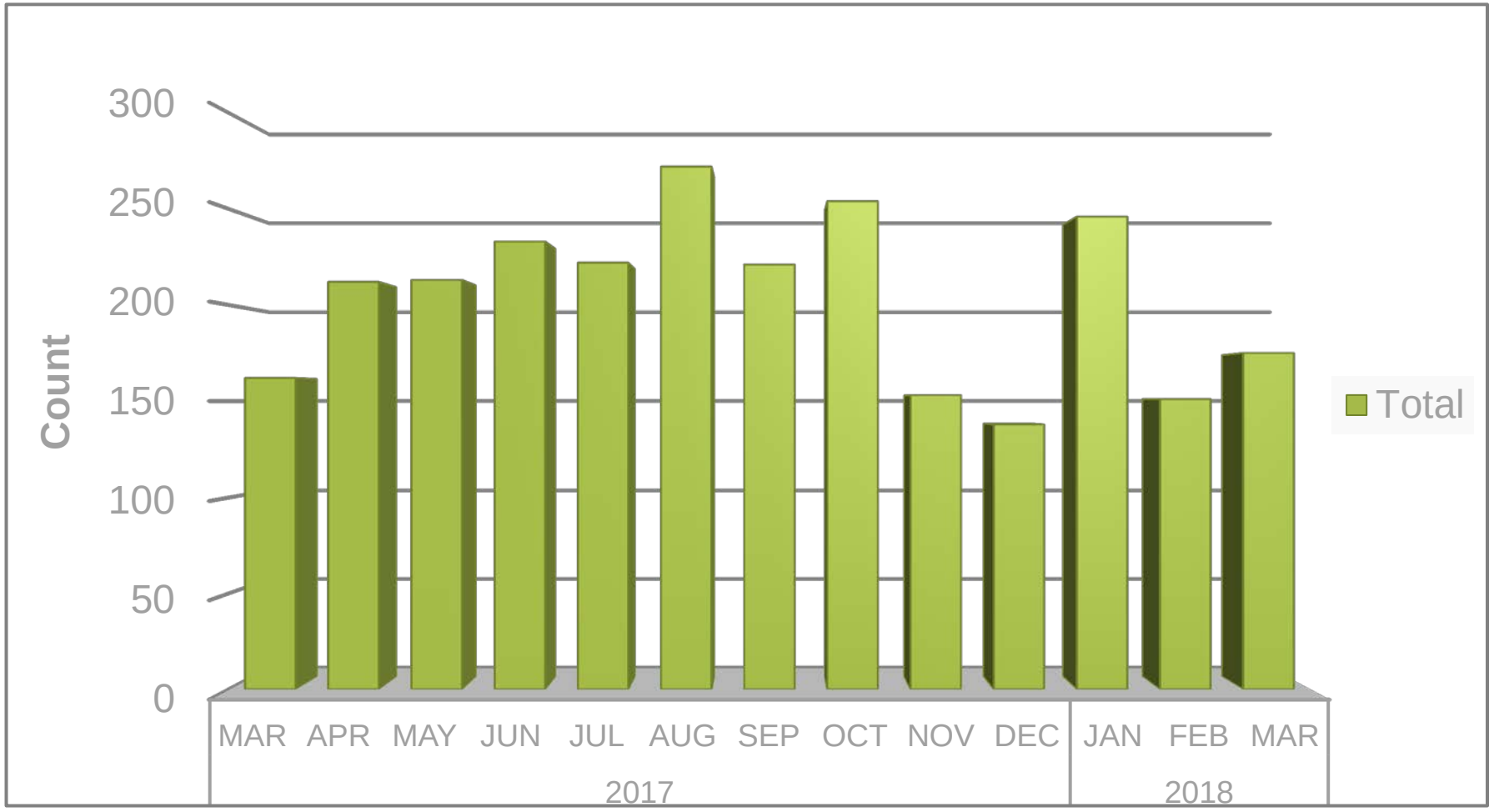
Summer	Winter
46	23





BACKGROUND

NUMBER OF SAMPLES RECEIVED (N=>2,600)



METHODOLOGY

WATER QUALITY INDICATOR METHODS

Water Quality Method	Water Quality Indicator	Standard Method reference	Limit of Detection	Turn-Around-Time
Multiple Tube Fermentation (MTF)	Total Coliforms	9221C	18 MPN/ 100 mL	2-4 days
	Fecal Coliforms	9221E		2-5 days
Defined Substrate Test (DST)	Total Coliforms	9223	10 MPN/100 mL	18 hours
	E. Coli	9223		
Membrane Filtration (MF)	Total Coliforms	9222B (mEndo Agar)	2 CFU/ 100 mL	24 hours
	Fecal Coliforms	9222E (mFC Agar)		

PRELIMINARY DATA

TIME

COMPARISON OF TURN-AROUND-TIME OVER A ONE YEAR PERIOD

Method	Q1 (hours)	Q2 (hours)	Q3 (hours)	Q4 (hours)	Mean (hours)
Defined Substrate Test	21 ± 1	22 ± 1	22 ± 1	21 ± 2	22
Membrane Filtration	26 ± 2	26 ± 1	26 ± 1	25 ± 1	26
Multiple Tube Fermentation	68 ± 27	65 ± 25	67 ± 26	67 ± 29	67

- TAT is from time of receipt to time that the results are reported.
- DST has the shortest reporting time, averaging 4 hours less than MF.

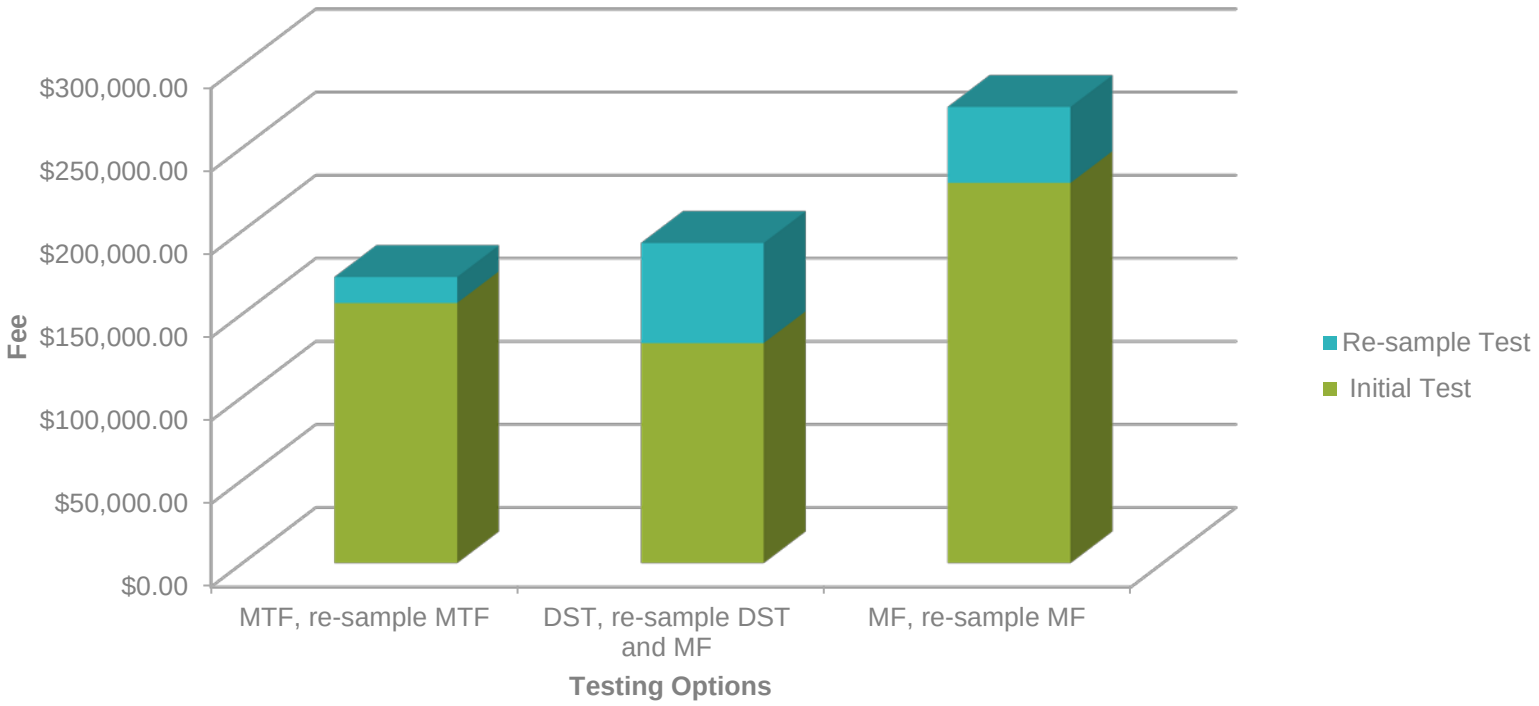
TIME

SCENARIOS FOR SAMPLES RECEIVED AT SAN DIEGO COUNTY PUBLIC HEALTH LABORATORY

Scenario	Time Sample Received	Time Sample Reported Next Day	PHL must receive re-sample by	Amount of time to retrieve a re-sample	Pros	Cons
Initial Sample	10:00 am	8:00 am (DST) vs. 12:00pm (MF)	4:30 pm (DST) vs. 3:30pm (MF)	8 hours (DST) vs. 3 ½ hours (MF)	• Results can be received by 8:00 am the next morning. • More time is allowed to retrieve re-samples when results are above actionable levels. vs. Results are more accurate	Results above actionable level may be false positive vs. • Less time allowed to re-sample. • Re-sample results will be sent after hours and positive re-sample must to be collected the next day.
Re-Sample	4:30 pm (DST) vs. 3:30 pm (MF)	2:30 pm (DST) vs 5:30 pm (MF)	4:30 pm (DST) vs. Next Day (MF)	2 hours (DST) vs. Must collect next day, 14 ½ hours minimum (MF)		

COST

COMPARISON OF FEES FOR FY 18-19



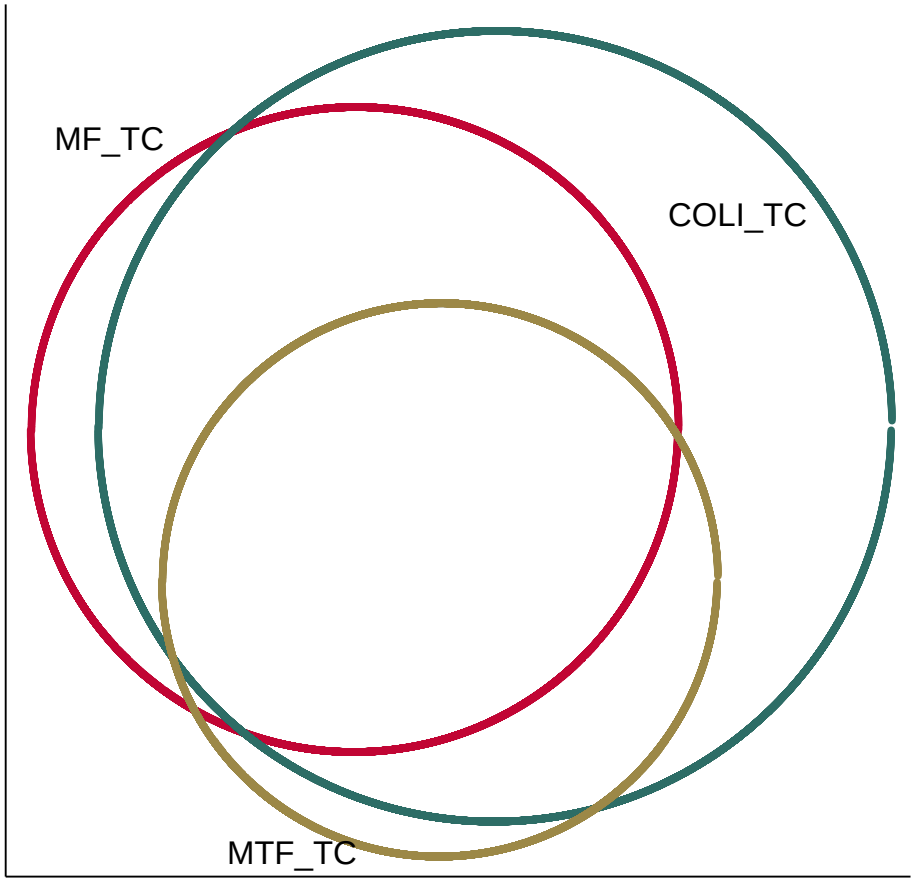
Cost includes employee time and materials to perform each assay

ACCURACY OF TOTAL COLIFORM TESTS AND ASSESSMENT OF ACTION LEVEL EVENTS

ACCURACY

QUANTIFIABLE/VALID RESULTS

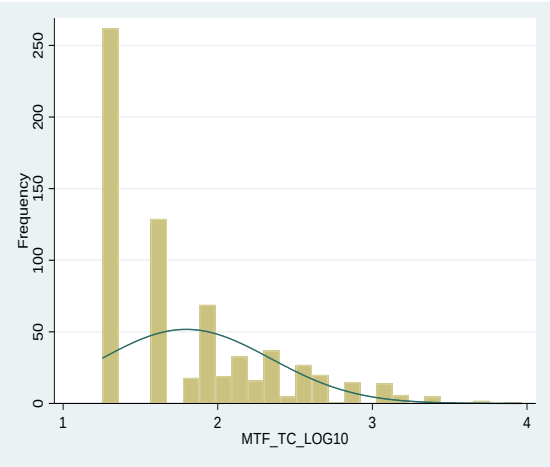
- Result remove <, >
- MTF and DST= 942
- MTF and MF = 697
- DST and MF = 1192
- **All 3 methods = 680**

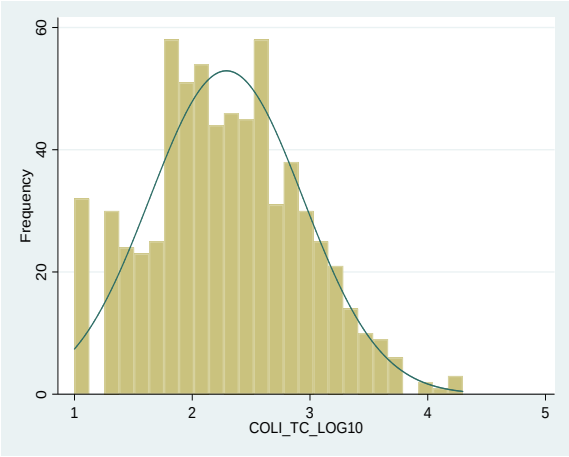


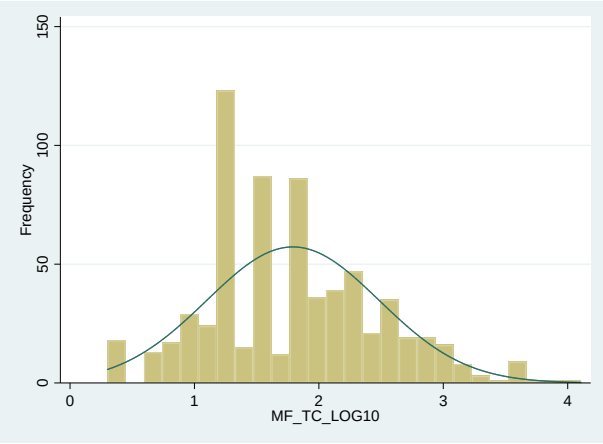
ACCURACY

LOG TRANSFORMATION FOR 680 RESULTS

Raw number	MTF_TC	DST_TC	MF_TC
Mean	191.4	618.8	260.3
Geometric mean	62.5	195.1	61.9
Log transformed	MTF_TC	DST_TC	MF_TC
Mean	1.796	2.290	1.792
Geometric mean	1.724	2.192	1.637

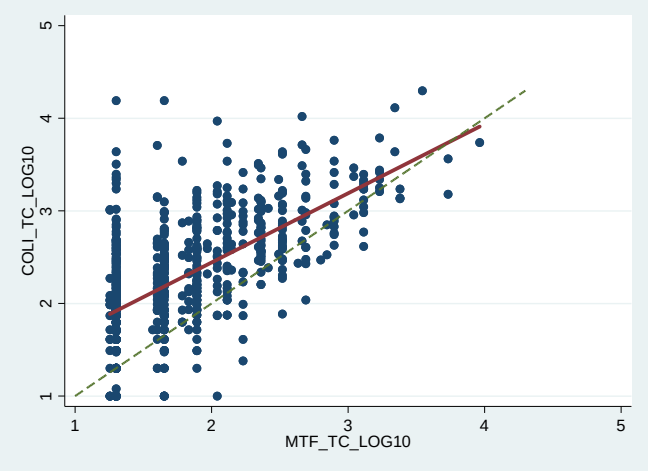


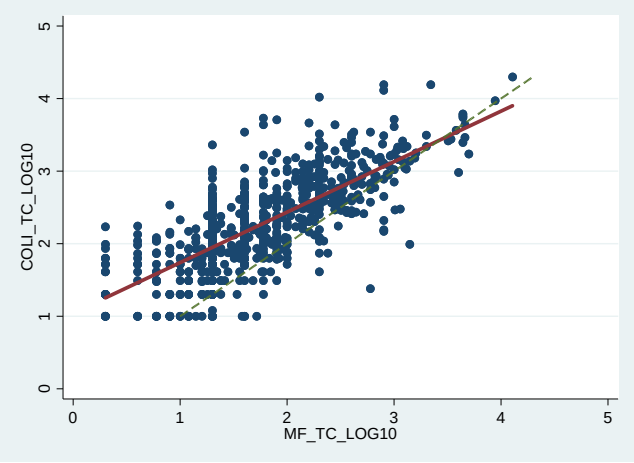




ACCURACY

LOG10 TRANSFORMATION FOR 680 RESULTS





ACCURACY

STATISTICAL CALCULATIONS

- Kendall's (nonparametric test of concordance)
  - Coefficient is: 0.775 ($p<0.001$)
  - The results from all three tests are not significantly different when compared case-wise.
- Index of Agreement
  - MTF to DST = 0.690
  - DST to MF = 0.758
  - MF to MTF = 0.836

ACTION LEVEL EVENTS

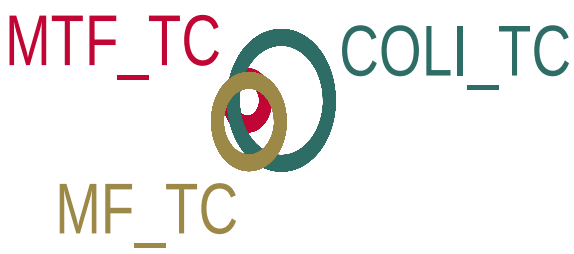
TOTAL COLIFORM (e10,000)

Comparison	Total tests	Results below actionable level	Results above actionable level
MTF_TC	2237	2,232 (99.8%) Includes <18	5 (0.2%) Includes >16000
DST_TC	2237	2,214 (99.0%) Includes <10 & <100	23 (1.0%) Includes >24196
MF_TC	2174	2,171 (99.9%) Includes <2, <20, <200,	3 (0.1%) Includes >16000

ACTION LEVEL EVENTS

TOTAL COLIFORMS BY BEACH

Beach	COLI_TC	MTF_TC	MF_TC	ALL*	Total
1	1		1		1
2	1	1	1	1	1
3	1				1
4	1				1
5			1		1
7	1				1
8	2				2
Total	7	1	3	1	8



TOTAL COLIFORM SUMMARY

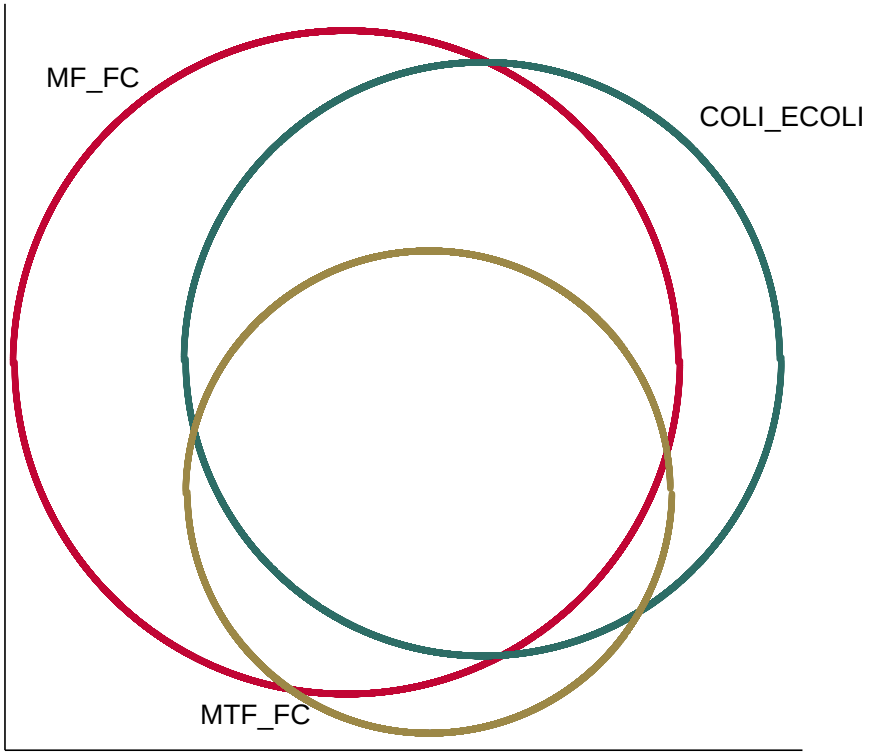
- After transformation MTF_TC results within LOQ were skewed and a larger portion of results were lower numbers
- Comparison (Kendall test) of all 3 TC tests (n=680) indicated there was no significant difference between results
- All methods were acceptable as an alternative method by the index of agreement calculation
- DST_TC had the largest percentage of LOQ results (89%)
- Over 99% of the results were below action levels.
- One event (13%) was above action level and in agreement across all three methods

ACCURACY OF FECAL COLIFORMS/*E.COLI*
AND
ASSESSMENT OF ACTION LEVEL EVENTS

ACCURACY

QUANTIFIABLE/VALID RESULTS

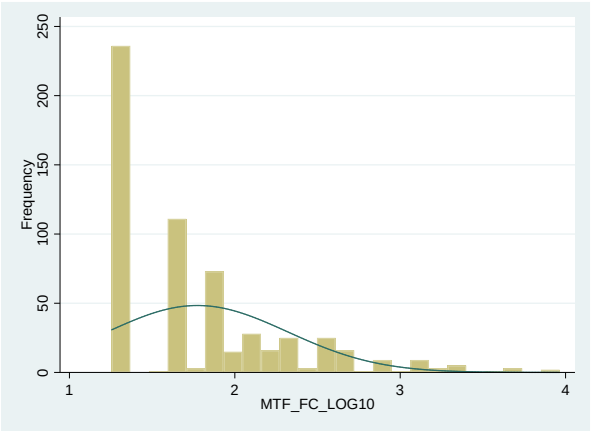
- Remove <, >
- MTF and DST = 991
- MTF and MF = 711
- DST and MF = 641
- **All 3 methods = 586**

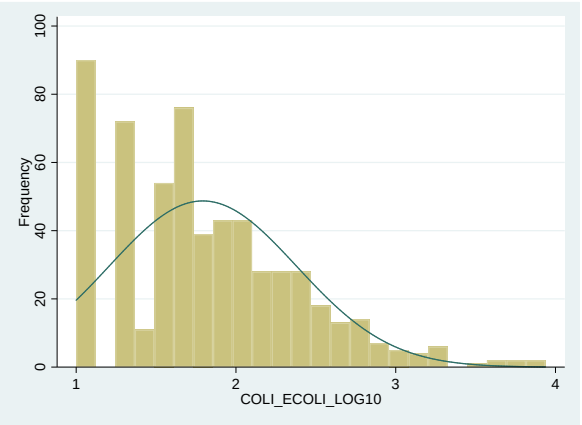


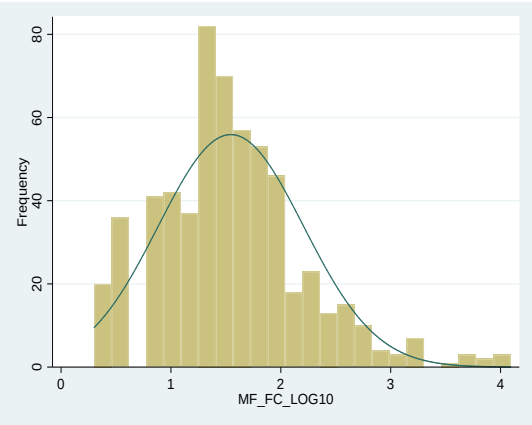
ACCURACY

LOG TRANSFORMATION FOR 586 RESULTS

Raw number	MTF_FC	DST_E.COLI	MF_FC
Mean	206.3	210.0	209.5
Geometric mean	59.4	62.1	35.1
Log transformed	**MTF_FC**	**DST_E.COLI**	**MF_FC**
Mean	1.774	1.793	1.545
Geometric mean	1.703	1.701	1.393

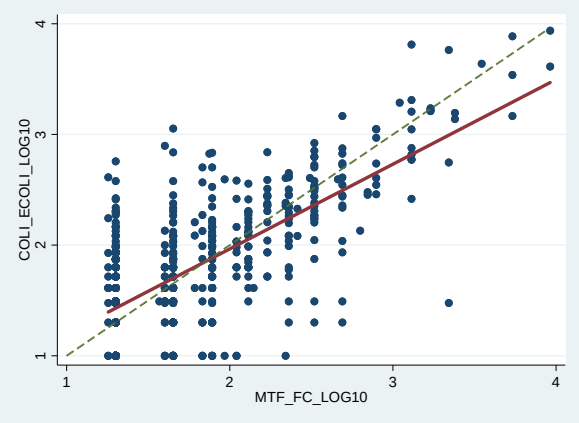


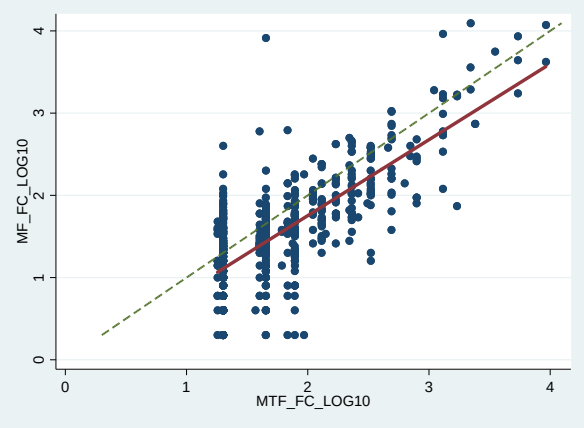


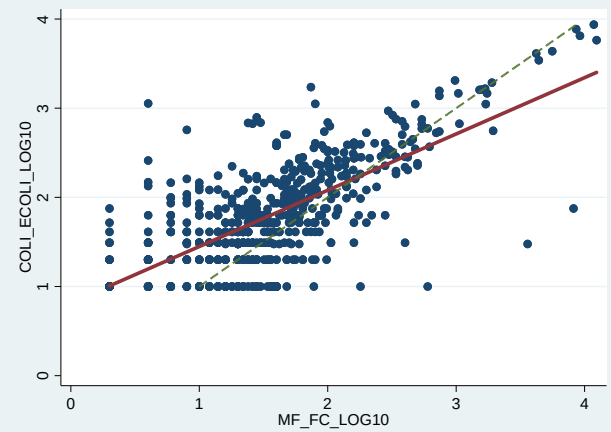


ACCURACY

LOG10 TRANSFORMATION FOR 586 RESULTS







ACCURACY

STATISTICAL CALCULATIONS

- Kendall's (nonparametric test of concordance)
  - Coefficient = 0.751 ($p<0.001$)
  - Results from all three tests are not significantly different when compared case-wise
- Index of Agreement
  - MF to MTF = 0.831
  - DST to MF = 0.806
  - MTF to DST = 0.842

ACTION LEVEL EVENTS

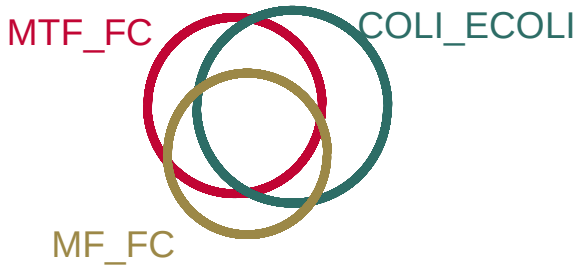
FECAL COLIFORMS/ E.COLI (e400)

Comparison	Total tests	Results below actionable level	Results above actionable level
MTF_FC	2237	2,181 (97.5%) Includes <18	56 (2.5%) Includes >16000
DST_E.COLI	2237	2,170 (97.0%) Includes <10 & <100	67 (3.0%) Includes >24196
MF_FC	2104	2,057 (97.8%) Includes <2, <20, <200,	47 (2.2%) Includes >12000

ACTION LEVEL EVENTS

FECAL COLIFORMS/E.COLI BY BEACH

Beach	DST_ECOLI	MTF_FC	MF_FC	ALL*	Total
1	8	7	7	7	8
2	2	4	3	1	6
3	2	2	1	1	2
4	1		2		3
5	3	1			3
6	16	19	16	13	21
7	13	2	3	1	15
8	3	5	4		9
9	10	9	5	3	15
10	5	4	6	2	10
Total	63	53	47	28	92



FECAL COLIFORM/E. COLI SUMMARY

- After transformation, DST_TC and MTF_TC results within LOQ were skewed and a larger portion of results were lower numbers
- Comparison (Kendall test) of all 3 FC tests (n=582) indicated there was no significant difference between results
- All methods were acceptable as an alternative method by the index of agreement calculation
- MF_FC had the largest percentage of LOQ results (68%)
- Over 97% of the results were below action level event
- 28 events (30%) that are above action level across all three methods
- Higher concordance across the three methods depending on the beach

ACTION LEVEL EVENT SUMMARY

COMPARISON OF TOTAL COLIFORM AND FECAL COLIFORM/*E. COLI*

- Multiple Tube Fermentation
  - 1 sample was above action level event for both total coliforms and fecal coliforms/E.coli
  - 41 samples were above action levels for fecal coliforms while below for total coliforms
- Defined Substrate Testing
  - 2 sample was above action level event for both total coliforms and fecal coliforms/E.coli
  - 51 samples were above action levels for fecal coliforms while below for total coliforms
  - 5 samples were above action levels for total coliforms while below for fecal coliforms
- Membrane Filtration
  - 2 sample was above action level event for both total coliforms and fecal coliforms/E.coli
  - 34 samples were above action levels for fecal coliforms while below for total coliforms
  - 1 samples were above action levels for total coliforms while below for fecal coliforms

OVERALL SUMMARY

- Results below actionable level represent over 99% for total coliforms and 97% for fecal coliform/E.coli across all methods.
- Only 3% of the results are actionable
- Kendall's test demonstrates that the methods are **not** significantly different.
- The index of agreement for meets or exceeds the EPA guideline of 0.7, making the DST and MF acceptable as an alternative method.
- DST has the shortest time to a valid result, which widens the window of opportunity to conduct re-sampling and supplemental testing.
- DST is less expensive than MF

RECOMMENDATIONS

METHOD	ACCURACY	TIME	COST	SCORE
DEFINED SUBSTRATE (DST)	1	3	3	**7**
MEMBRANE FILTRATION (MF)	3	2	1	6
MULTIPLE TUBE FERMENTATION (MTF)	2	1	2	5

1=poor, 2=medium, 3= best

- The combination of accuracy, timeliness, and cost effectiveness supports the use of DST for initial sampling
- In the interest of accuracy, a process using DST for initial sampling, followed by DST+MF for re-sampling will provide the best protective assessment of San Diego County's recreational beach waters

COLLABORATORS

SAN DIEGO COUNTY
HEALTH AND HUMAN SERVICES AGENCY

- Brett Austin, Lab Director
- Syreeta Steele, PhD, Asst Lab Director
- Maria Victorio, Senior Public Health Microbiologist
- All staff in PHL

SAN DIEGO COUNTY
LAND AND USE ENVIRONMENT GROUP

- Lars Seifert, Land and Water Quality Division Chief
- Keith Kezer, Project Manager
- Dominique Edwards, Environmental Health Specialist II
- All Beach and Bay staff

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COUNTY OF SAN DIEGO HHSA HEALTH AND HUMAN SERVICES AGENCY PUBLIC HEALTH SERVICES

On May 17, 2016, the County of San Diego Health and Human Services Agency Division of Public Health Services received accreditation from the Public Health Accreditation Board.

REFERENCES

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Questions?

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