Chemical Testing of Commercial Vessel Personnel
An Analysis of Archived Test Results

by

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ABSTRACT

The United States Coast Guard implemented chemical testing to discourage drug and alcohol use by commercial vessel personnel, reduce the potential for marine casualties related to drug and alcohol use, and enhance the safety of the maritime transportation industry. This study shows the extent chemical testing might achieve these U.S. Coast Guard goals through a secondary data analysis of samples from two archived databases from 2003-2011. The first database is the Management Information System containing drug testing results marine employers submit to the Coast Guard each year. The second consists of Serious Marine Incident reports containing Post-Accident drug and alcohol test results from two vessel categories – those with no crewmember chemical testing requirements except for Post-Accident drugs and alcohol and the other with comprehensive crewmember chemical testing requirements. Chemical testing includes Pre-Employment, Periodic, Random, Reasonable Cause, and Post-Accident. Alcohol testing is conducted Post-Accident only. This study compared the following: 1) Post-Accident drug and alcohol positivity rates between the two vessel categories; 2) Yearly ratios of Post-Accident drug and alcohol positive tests to serious marine incidents of each vessel category; and, 3) Random to Post-Accident drug test positivity rates from all commercial vessel personnel subject to chemical testing. Using percentages, tables, graphs, the correlation coefficient, linear regression, and the two proportion *z*-test, this study found that chemical testing appears to have discouraged drug and alcohol use by commercial vessel personnel, reduced the potential for marine casualties related to drug and alcohol use, and enhanced the safety of the maritime transportation industry.

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I. INTRODUCTION

A. OVERVIEW

The U.S. Coast Guard issues and enforces regulations to promote safety of life and property on and under the high seas and waters subject to the jurisdiction of the United States[1] 14 U.S.C. § 2 (2006). It also exercises general regulatory authority over the Merchant Marine, its vessels, and its personnel 46 U.S.C. § 2103 (2006). Pursuant to that authority, among others, the Coast Guard implemented chemical testing programs "to discourage drug and alcohol use by commercial vessel personnel, reduce the potential for marine casualties related to drug and alcohol use, and enhance the safety of the maritime transportation industry" Programs for Chemical Drug and Alcohol Testing of Commercial Vessel Personnel, 53 Fed. Reg. Nov. 21, 1988, p. 47,064. Title 46 U.S.C. § 7702(c)(2) (2006) also mandates chemical testing commercial vessel personnel that are holders of Coast Guard issued Credentials for use of alcohol or dangerous drugs.

B. CHEMICAL TESTING PROCESS

"*Chemical testing* means a scientifically recognized test which analyzes an individual's breath, blood, urine, saliva, bodily fluids, or tissues for evidence of dangerous drug use" 46 C.F.R. § 16.105 (2012). "*Dangerous drug* means a narcotic drug, a controlled substance, or a controlled substance analog as defined in section 102 of

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[1] The author is the Chief Administrative Law Judge for the U.S. Coast Guard, an agency of the U.S. Department of Homeland Security. Coast Guard Administrative Law Judges hear and decide cases Investigating Officers initiate to suspend or revoke Merchant Marine Credentials of commercial vessel personnel for misconduct, negligence, incompetence, violation of law or regulation, and drug use. Coast Guard Administrative Law Judges also hear and decide cases for other Homeland Security agency components as well as other agencies. The author's opinions expressed herein are his own and do not reflect the views of the U.S. Department of Homeland Security, the Commandant of the Coast Guard, or the Office of Chief Administrative Law Judge, U.S. Coast Guard.

the Comprehensive Drug Abuse and Control Act of 1970 (21 U.S.C. 820)" 46 C.F.R. § 16.105 (2012). As used in this study, the term "drug test" is a test of an individual's urine for evidence of dangerous drug use 49 C.F.R. pt. 40, subpts. C through F. The types of chemical testing include Pre-Employment, Periodic, Random, Reasonable Cause, and Post-Accident[2] 46 C.F.R. §§ 16.201-250 (2012).

According to 46 C.F.R. § 4.06-15(a)(2)(2012), alcohol testing of commercial vessel personnel is performed with devices listed on either the Conforming Products List titled "Modal Specifications for Devices To Measure Breath Alcohol" or "Conforming Products List of Screening Devices To Measure Alcohol in Bodily Fluids." For commercial vessel personnel, Post-Accident alcohol testing is ordered pursuant to 46 C.F.R. §§ 16.240 and 16.500 (2012) for serious marine incidents and 33 C.F.R. § 95.035(a)(1) (2012) when "[t]he individual was directly involved in the occurrence of a marine casualty as defined in Chapter 61 of Title 46, United States Code." When comparing Post-Accident drug and alcohol test positivity rates between crewmembers subject to chemical testing and crewmembers not otherwise subject to chemical testing except for Post-Accident tests, this study focuses only on the positivity rates from serious marine incidents, not all marine casualties.

As prescribed in 46 C.F.R. § 16.201(a) (2012), marine employers must initiate and conduct chemical testing as required by 46 C.F.R. pt. 16, subpt. B and in accordance with the procedures detailed in 49 C.F.R. pt. 40. With very few exceptions, marine employers of commercial fishing vessel crewmembers are exempt from initiating and

[2] Employees previously testing positive must take Follow-Up and Return-To-Duty drug tests in accordance with 49 C.F.R. §§40.305 and 40.307 (2012). Those tests are not the subject of this study.

conducting chemical testing except for Post-Accident drugs and alcohol under 46 C.F.R. § 16.240. Each urine specimen is chemically tested in accordance with the procedures in 49 C.F.R. pt. 40 for the following dangerous drugs: marijuana, cocaine, opiates, phencyclidine (PCP); and amphetamines 46 C.F.R. § 16.103 (2012); 49 C.F.R. § 40.85 (2012). The term "marine employer" means the owner, managing operator, charterer, agent, master, or person in charge of a vessel, other than a recreational vessel" 46 C.F.R. § 16.105 (2012). Drug testing must be conducted by laboratories certified by the U.S. Department of Health and Human Services under the National Laboratory Certification Program for all testing conducted under 49 C.F.R. pt. 40 49 C.F.R. § 40.81(a) (2012).

C. CONSEQUENCES OF FAILING A CHEMICAL TEST

The law as well as marine employers require certain commercial vessel crewmembers to hold Coast Guard issued Credentials.[3] Credentials determine and verify a crewmember's qualifications and competencies to serve on merchant vessels. Under 46 C.F.R. § 16.201(c) (2012), if an individual holding a Credential fails a chemical test, the employer, prospective employer, or sponsoring organization must report the test results in writing to the Coast Guard.[4] The employer, prospective employer, or sponsoring organization must deny the individual employment as a crewmember or remove the individual from duties directly affecting the safe operation of the vessel as soon as practicable. Because chemical test results are reported to the Coast Guard, the individual

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[3]The term "Credential" refers to Merchant Mariner's Document, Merchant Mariner's License, STCW Endorsement, and Certificate of Registry, as well as the Merchant Mariner's Credential [46 C.F.R. § 16.105 (2012)]. STCW Endorsement means the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended 1995 46 C.F.R. §§ 10.101, 10.103(b) (2012).

[4] See also 46 U.S.C. § 7706 (2006) directing other federal agencies employing Credentialed crewmembers to forward test results to the Coast Guard.

holder of a Coast Guard issued Credential failing the chemical test is also subject to suspension and revocation proceedings against his or her Credential in accordance with 46 U.S.C. §§ 7701-7705 (2006), 46 C.F.R. pt. 5, and 33 C.F.R. pt. 20. The purpose of suspension and revocation proceedings is to promote safety at sea 46 U.S.C. § 7701(a) (2006). Those proceedings are remedial, not penal in nature and are intended to help maintain standards for competence and conduct essential for the promotion of safety at sea 46 C.F.R. § 5.5 (2012).

If the individual failing a chemical test for dangerous drugs does not hold a Credential, 46 C.F.R. § 16.201(d) (2012) requires marine employers to deny the individual employment as a crewmember or remove the individual from duties directly affecting the safe operation of the vessel as soon as possible. Under 46 C.F.R. § 16.201(f) (2012), marine employers may not re-employ any individual described in 46 C.F.R. §§ 16.201(c) and (d) aboard a vessel until the individual has completed the recommendations of the Substance Abuse Professional as described in 49 C.F.R. §§ 40.281-313 (2012). Further, the Medical Review Officer (MRO) must determine the individual is drug-free and that the subsequent risk of drug use by that person is sufficiently low to justify a return to work. Moreover, the crewmember testing positive must agree to be subject to increased, unannounced testing for a minimum of six (6) tests in the first year after the crewmember returns to work as required in 49 CFR pt. 40 and for any additional period as determined by the Substance Abuse Professional or the MRO up to a total of 60 months. The first test is a Return-To-Duty test performed under direct observation. Subsequent to that test, Follow-Up tests are also performed under direct observation as ordered by the Substance Abuse professional or the MRO.[5]

If the Administrative Law Judge in suspension and revocation proceedings finds the positive chemical test was ordered in accordance with 46 C.F.R. pt. 16 and tested in accordance with the procedures in 49 C.F.R. pt. 40, the individual is presumed to be a user of dangerous drugs 46 C.F.R. §§ 16.201(a) and (b) (2012). Under 46 U.S.C. § 7704(c) "[i]f it is shown that a [Credential] holder has been a user of, or addicted to, a dangerous drug, the license, certificate of registry, or merchant mariner's document (currently referred to as Credentials) shall be revoked unless the holder provides satisfactory proof that the holder is cured" (Emphasis and brackets added). The Administrative Law Judge must revoke the individual's Credential unless the individual rebuts the presumption that he or she is a user of dangerous drugs or provides satisfactory proof of cure.

D. CURE

Credentialed crewmembers testing positive are subject to having their credentials revoked in Coast Guard suspension and revocation proceedings. To provide satisfactory proof of cure, the current practice is for the crewmember/respondent to enter into a settlement agreement with the Coast Guard. This process allows the individual to deposit his or her Credential(s) with the Coast Guard pending successful completion of a recognized drug rehabilitation program followed by a one year period of remaining drug free, evidenced by passing 12 random, unannounced drug tests and attending prescribed

[5] Interview with Mr. Robert C. Schoening, U.S. Coast Guard Drug and Alcohol Program Manager, August 27, 2012.

Narcotics Anonymous (NA) and/or Alcoholic Anonymous (AA) meetings. The Coast Guard will return the Credential(s) to the individual upon the following conditions: successfully completing drug rehabilitation (usually 2 months); remaining drug free for one year following drug rehabilitation as evidence by passing the prescribed, unannounced, random drug tests; attending NA/AA meetings as agreed upon; and, obtaining clearance from the Substance Abuse Professional and the MRO that the individual is drug-free and the risk of subsequent dangerous drug use is sufficiently low to justify his or her return to work. During the period of Credential deposit, the individual is not permitted to work in any position requiring a Coast Guard issued Credential (Brudzinski, 2010, April 13).

E. REQUIRED CHEMICAL TESTING

Pre-Employment. An individual seeking employment as a crewmember in a position involving the safe operation of a vessel must pass a Pre-Employment chemical test for dangerous drugs as per 46 C.F.R. § 16.210(a) (2012). A marine employer may waive a Pre-Employment test if the individual provides satisfactory evidence of passing a chemical test for dangerous drugs required by 46 C.F.R. Part 16 within the previous six (6) months with no subsequent, positive drug tests during the remainder of the six month period; or, during the previous 185 days had been subject to a Random testing program required by 46 C.F.R §16.230 for at least 60 days and did not fail or refuse to participate in any chemical test required under 46 C.F.R. pt. 16 as per 46 C.F.R. § 16.210(b) (2012). After the potential crewmember passes the Pre-Employment drug test and is hired, that individual is further subject to unannounced Random tests, Reasonable Cause tests, and Post-Accident tests as per 46 C.F.R. pt.16, subpt. B (2012).

Random. Title 46 C.F.R. § 16.230 (2012) requires marine employers to randomly drug test at least 50% of their crewmembers that work in safety-sensitive positions each year, performed at least once per quarter. For example, if the marine employer has 200 covered employees subject to mandatory chemical testing, the marine employer must conduct at least 25 random tests each quarter of that year, for a total of 100 tests (.50 x 200). Crewmembers previously selected in the first quarter's test are also are subject to being selected for the next three quarters in the same fashion as those crewmembers not previously selected.[6] The Coast Guard may adjust the 50% annual percentage rate downward to 25% of covered employees if the overall, yearly drug testing reports received from all employers show the Random positive rate to be less than 1% for two consecutive calendar years. Conversely, if the minimum annual percentage rate for Random drug testing is 25% and the drug testing reports from marine employers from the previous year indicate that the Random positive rate is equal to or greater than 1%, the Coast Guard will increase the minimum annual percentage rate for Random testing back to 50% for the following calendar year in accordance with 46 C.F.R. § 16.230 (2012).

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[6] Selecting crewmembers for Random testing is described in 46 C.F.R. § 16.230(c) (2012) as follows:

> The selection of crewmembers for random drug testing shall be made by a scientifically valid method, such as a random number table or a computer-based random number generator that is matched with crewmembers' Social Security numbers, payroll identification numbers, or other comparable identifying numbers. Under the testing frequency and selection process used, each covered crewmember shall have an equal chance of being tested each time selections are made and an employee's chance of selection shall continue to exist throughout his or her employment. As an alternative, random selection may be accomplished by periodically selecting one or more vessels and testing all crewmembers covered by this section, provided that each vessel subject to the marine employer's test program remains equally subject to selection.

Periodic. Under 46 C.F.R. 16.220 (2012), the Coast Guard requires Periodic testing when it issues an initial Credential to a crewmember and any subsequent raise in grade, reissuance, or annual physical. As with Pre-Employment testing, the crewmember need not submit evidence of passing a chemical test for dangerous drugs if he or she provides satisfactory evidence of passing such a test as required by 46 C.F.R. pt. 16 within the past previous six (6) months with no subsequent positive drug tests during the remainder of the six month period; or, during the previous 185 days had been subject to a Random testing program required by 46 C.F.R §16.230 (2012) for at least 60 days and did not fail or refuse to participate in any chemical test required under 46 C.F.R. pt. 16.

Reasonable Cause. Title 46 C.F.R. § 16.250 (2012) prescribes marine employers shall require any crewmember engaged or employed on board a vessel owned in the United States that is required by law or regulation to engage, employ, or be operated by an individual holding a Credential issued by the Coast Guard who is reasonably suspected of using a dangerous drug to undergo a chemical test for the use of dangerous drugs. "The employer's suspicion must be based on a reasonable and articulable belief that the individual has used a dangerous drug based on direct observation of specific, contemporaneous, physical, behavioral, or performance indicators of probable use" as stated at 46 C.F.R. § 16.250(b) (2012).

Post-Accident tests from serious marine incidents. Title 46 C.F.R. § 16.240 (2012) requires marine employers to ensure all persons directly involved in a serious marine incident are chemically tested for evidence of dangerous drugs and alcohol in accordance with the requirements of 46 C.F.R. subpt. 4.06. A serious marine incident is defined in 46 C.F.R. § 4.03-2 (2012) and includes any incident described as a Marine

Casualty or Accident in 46 C.F.R. 4.03-1 (2012) for which the owner, agent, master, operator, or person in charge shall notify the Coast Guard in accordance with 46 C.F.R. § 4.05.1 (2012).[7] Serious Marine Incidents include one or more deaths; any injury to a crewmember, passenger, or other person which requires professional medical treatment beyond first aid; damage to property in excess of $100,000; actual or constructive loss of a vessel; a discharge of 10,000 gallons or more of oil into the navigable waters of the United States; and, discharges of a reportable quantity of hazardous substance into the environment or navigable waters of the United States.

Under 46 C.F.R. § 4.05-1 (2012) the Coast Guard must be notified of the following: an unintended grounding, or an unintended strike of (allusion with) a bridge; an intended grounding or an intended strike of a bridge that creates a hazard to navigation, the environment, or the safety of a vessel; a loss of main propulsion, steering, or any associated component or control system that reduces the maneuverability of the vessel; an occurrence that adversely affects the vessel's seaworthiness including fire or flooding; loss of life; injury requiring professional medical treatment beyond first aid; property damage in excess of $25,000; and, an occurrence involving significant harm to the environment.

Title 46 C.F.R. § 4.06-1(b) (2012) prescribes once a marine employer determines a casualty or incident is or is likely to become a serious marine incident, the marine

[7] Ordinary Marine Casualties or Accidents defined in section 4.03-1 generally include any fall overboard, injury, or loss of life of any person and any occurrence involving a vessel that results in grounding, stranding, foundering, flooding, collision, allusion, explosion, fire, reduction or loss of a vessel's electrical power, propulsion, or steering capabilities. Marine Casualties or Accidents also include failures that impair any aspect of a vessel's operation; any other circumstances that might affect or impair a vessel's seaworthiness, efficiency, or fitness for service or route; and, any incident involving significant harm to the environment, among other things.

employer shall take all practicable steps to have each crewmember on board the vessel who is directly involved in the incident chemically tested for evidence of drug and alcohol use. Alcohol testing must occur within two hours of the serious marine incident, if practicable; drug testing must occur within 32 hours of the serious marine incident 46 C.F.R. § 4.06-3 (2012).

F. RECORDS AND REPORTS

In addition to the immediate notice required in section 4.05-1, the owner, agent, master, operator, or person in charge must prepare written report of any marine casualty required to be reported under § 4.05–1 within five days of the incident. This written report must be delivered to a Coast Guard Sector Office or Marine Inspection Office. It must be provided on Form CG-2692 (Report of Marine Accident, Injury or Death), supplemented as necessary by appended Forms CG-2692A (Barge Addendum) and CG-2692B (Report of Required Chemical Drug and Alcohol Testing Following a Serious Marine Incident) 46 C.F.R. 4.05-10(a) (2012). This is how the Coast Guard obtains Post-Accident chemical testing results from serious marine incidents in accordance with 46 C.F.R. § 4.06-3 (2012).

Marine employers are also required to maintain records of chemical tests and make those records available to the Coast Guard upon request 46 C.F.R § 16.260 (2012). Further, marine employers must submit yearly drug testing data and results on the U.S. Department of Transportation Drug and Alcohol Testing Management Information System (MIS) Data Collection Form to Commandant, (CG–INV), U.S. Coast Guard, 2100 2nd St. SW., Stop 7581, Washington, DC 20593–7581 46 C.F.R. §16.500 (2012); 49 C.F.R. pt. 40, Appendix H. The provisions in 49 C.F.R. pt. 40 for alcohol testing by

Department of Transportation (DOT) agencies do not apply to the Coast Guard or to marine employers. Marine employers are not required or permitted to submit alcohol testing data other than in accordance with the requirements of 46 C.F.R. § 4.06 (2012) for Serious Marine Incident reports as per 46 C.F.R. § 16.500(a)(2) (2012). Marine employers submit alcohol testing results on the Report of Required Chemical Drug and Alcohol Testing Following a Serious Marine Incident which supplements the Report of Marine Accident, Injury or Death, CG-2692B.[8]

G. EMPLOYEE ASSISTANCE PROGRAMS

Crewmembers are aware that a positive chemical test has serious consequences from loss of their employment to loss of their Coast Guard issued Credentials. Their employers make them aware through the company's policy and the Coast Guard makes those with Credentials aware during their licensing process. Yet, significant numbers of crewmembers still test positive, lose their employment, and, if they are Credential holders, are subject to suspension and revocation proceedings typically resulting in the loss of their Credentials unless they provide satisfactory proof that they are cured of dangerous drug use.

To assist crewmembers in avoiding dangerous drug use, the Coast Guard also requires marine employers to provide Employee Assistance Programs (EAP) for all crewmembers. Each EAP must include education and training on drug use for both crewmembers and supervisory personnel. The EAP must: 1) display and distribute informational material; 2) display and distribute a community service hot-line telephone

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[8] Under 46 C.F.R. §§ 4.06-70 and 16.115 (2012), marine employers failing to implement, conduct or comply with chemical testing requirements are subject to civil penalties.

number for crewmember assistance; and, 3) display and distribute the employer's policy regarding drug and alcohol use in the workplace 46 C.F.R. 16.401 (2012).

H. PURPOSE

As stated in the Final Rule, chemical testing's goals are "to discourage drug and alcohol use by commercial vessel personnel, reduce the potential for marine casualties related to drug and alcohol use, and enhance the safety of the maritime transportation industry."

Federally mandated chemical testing of commercial vessel personnel substantially impacts crewmembers as well as marine employers; however, its effects on discouraging drug and alcohol use, reducing the potential for marine casualties related to drug and alcohol use, and enhancing the safety of the maritime transportation have not been the subject of empirical study and to that extent remain largely unknown. Determining the extent chemical testing is discouraging drug and alcohol use, reducing the potential for marine casualties, and enhancing the safety of the maritime transportation industry is therefore appropriate for inquiry and is this study's purpose.

I. RESEARCH QUESTIONS AND HYPOTHESES

Research question number 1: To what extent, if any, has chemical testing discouraged drug and alcohol use by commercial vessel personnel? The following Hypotheses address that research question:

Hypothesis 1A: Yearly 2003-2011 Post-Accident drug test positivity rates from small passenger vessel crewmembers subject to chemical testing are significantly lower than yearly 2003-2011 Post-Accident drug test positivity rates from commercial fishing vessel crewmembers not otherwise subject to chemical testing.

Hypothesis 1B: Yearly 2003-2011 Post-Accident alcohol test positivity rates from small passenger vessel crewmembers subject to chemical testing are significantly lower than yearly 2003-2011 Post-Accident alcohol test positivity rates from commercial fishing vessel crewmembers not otherwise subject to chemical testing.

Hypothesis 1C: Yearly 2003-2011 Post-Accident drug test positivity rates from all crewmembers subject to chemical testing from all vessels are significantly lower than yearly 2003-2011 Post-Accident drug test positivity rates from commercial fishing vessel crewmembers not otherwise subject to chemical testing.

Research question number 2: To what extent, if any, does chemical testing reduce the potential for marine casualties related to drug and alcohol use? The following Hypotheses address that research question:

Hypothesis 2A: The yearly 2003-2011 ratios of Post-Accident positive drug tests per serious marine incident from small passenger vessel crewmembers subject to chemical testing are significantly lower than corresponding Post-Accident positive drug tests per serious marine incident from commercial fishing vessel crewmembers not otherwise subject to chemical testing.

Hypothesis 2B: The yearly 2003-2011 ratios of Post-Accident positive alcohol tests per serious marine incident from small passenger vessel crewmembers subject to chemical testing are significantly lower than corresponding Post-Accident positive alcohol tests per serious marine incident from commercial fishing vessel crewmembers not otherwise subject to chemical testing.

Research question number 3: To what extent, if any, does chemical testing enhance the safety of the maritime transportation industry? The following Hypothesis addresses that research question:

Hypothesis 3: Yearly 2003-2011 Post-Accident drug test positivity rates from all vessels with crewmembers subject to chemical testing will correlate positively and strongly with decreasingly lower Random drug test positivity rates from 2003-2011 for all vessels with crewmembers subject to chemical testing.

This study assumes the data reported to the Coast Guard was accurate; that small passenger vessel crewmembers have passed a Pre-Employment chemical prior to being hired and are aware they are still subject to Random, Reasonable-Cause, and Post-Accident chemical tests for drugs and alcohol; that commercial fishing vessel crewmembers are not subject to chemical tests except Post-Accident drugs and alcohol and may not be aware they are subject to Post-Accident chemical tests.

II. LITERATURE REVIEW

A. OVERVIEW

There are no empirical studies specifically concerning chemical testing of commercial vessel personnel. This might be attributed in part to the overall comprehensiveness of the regulations as described above; the “zero tolerance” sanctions for those crewmembers testing positive; and, the opportunities available to crewmembers to demonstrate they are cured of drug use so they can return to work. The lack of empirical studies on commercial vessel personnel chemical testing is not surprising because it is consistent with the relative dearth of empirical studies in transportation and workplace drug testing in general, especially in the last five years. This may be due in part to the difficulty in attributing drug testing directly to those areas it seeks to improve, such as work performance and safety. As shown in the literature review, empirical studies to measure drug testing’s effect on work performance and safety have met with mixed results, not because drug use has no effects on work performance or safety, but because of the methods used. Instead of attempting to measure specific areas of work performance or safety, this study measured the goals of federally mandated chemical testing as expressed in the final rule.

The Literature Review begins with a brief discussion of the reasons for implementing chemical testing followed by brief discussions of articles pertaining to the suspension and revocation process against credentialed crewmembers/mariners that test positive for dangerous drugs.[9] The “zero tolerance” nature of the suspension and revocation process is perhaps the major factor in discouraging drug use. The Literature

[9] For the purpose of this study, the terms “crewmember(s)” and “mariner(s)” are used interchangeably.

Review also acknowledges the constitutional issues surrounding mandatory drug testing. This study does not evaluate the suspension and revocation process nor does it discuss the constitutional aspects of mandatory drug testing; however, having a familiarity with these aspects is helpful in understanding the expressed goals of federally mandated chemical testing. It is also helpful to show the need for more empirical work on testing results.

The Literature Review then discusses articles on drug testing's limitations followed by discussions of articles on discouraging drug use, drug testing and accidents, and Quest Diagnostics' Drug Testing Index. It ends with a brief discussion of the most practical methods to evaluate federally-mandated chemical testing of commercial vessel personnel which leads to the methods employed in this study.

B. BACKGROUND

The Coast Guard initially expressed its reasons for implementing chemical testing in the Summary section of its Notice of Proposed Rulemaking as follows: "Through chemical testing, the Coast Guard expects to discourage drug and alcohol use by merchant marine personnel, an activity which adversely impacts the users, their shipmates, the marine industry, and the public in general. Chemical testing should also reduce the potential for marine casualties related to drug and alcohol use" (proposed, 53 Fed. Reg. Jun. 8, 1988, p. 25,926). The Summary section of the Final Rule, entitled "Programs for Chemical Drug and Alcohol Testing of Commercial Vessel Personnel" further articulated those reasons as follows:

> These regulations require the establishment of anti-drug programs to reduce the incidence of drug abuse by commercial vessel personnel. These programs include pre-employment, periodic, random, post-accident and reasonable cause testing. The post-accident portion of the program also involves testing for alcohol use. The Coast Guard believes these rules will

> discourage drug and alcohol use by commercial vessel personnel, reduce the potential for marine casualties related to drug and alcohol use, and enhance the safety of the maritime transportation industry (Programs for Chemical Drug and Alcohol Testing of Commercial Vessel Personnel, 53 Fed. Reg. Nov. 21, 1988, p. 47,064).[10]

Shortly after the Coast Guard implemented chemical testing, one law review article entitled "Drug and Alcohol Testing of Maritime Personnel" addressed the constitutionality of on-the-job drug testing (Wright, 1989). The Wright article discusses the regulations in light of the Supreme Court's decisions in *Skinner v. Railway Labor Executives Association*, 409 U.S. 602 (1989) (warrant not required for safety sensitive positions) and *National Treasury Employees Union v. Von Raab*, 409 U.S. 656 (1989) (drug testing must be reasonable). In both cases, the Supreme Court of the United States found mandatory drug testing did not violate the Fourth Amendment because the Government had a compelling interest in ensuring public safety. Wright analyzes those decisions and discusses the likely impact on Coast Guard regulations mandating chemical testing of commercial vessel personnel.

Wright finds the regulations at 46 C.F.R. pt. 16 are probably constitutional because little or no discretion is permitted in implementing them. The scope of permissible testing is well defined; however, he finds the privacy interests of maritime employees are severely infringed upon which would tend not to support the regulations' constitutionality. But, Wright recognizes the maritime industry has always been highly

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[10] In 1988, the Coast Guard was part of the U.S. Department of Transportation. The Coast Guard became part of the U.S. Department of Homeland Security pursuant to § 888 of "The Homeland Security Act of 2002," Pub. L. 107-296, 116 Stat. 2135, 2249 (Nov. 25, 2002). Implementing chemical testing was done in concert with other Department of Transportation modal agencies. See the Department of Transportation's Office of Drug and Alcohol Policy and Compliance website at http://www.dot.gov/odapc/oamanagers.html.

regulated and that these regulations narrowly define the types of drugs to be tested for, the circumstances under which the tests may be performed, and who may perform them.

Most importantly, Wright recognizes that the Government's interest in maintaining safety in the maritime industry is very significant and that "it will be up to a federal judge or perhaps the Supreme Court to make a policy decision regarding whose interest is more important – that of the Government in maintaining safety in the maritime industry, or that of the employees in maintaining their privacy" (Wright, 1989, pp. 556-57). The constitutional aspects of federally mandated drug testing have survived many constitutional tests so it appears testing commercial vessel personnel in accordance with the procedures described above are here to stay.

Concerning what happens to test results after marine employers forward them to the Coast Guard, only three articles appeared in the literature pertaining to federally-mandated chemical testing of commercial vessel personnel. The first article concerns those crewmembers holding Coast Guard Credentials and testing positive for dangerous drugs. It provides guidance to maritime attorneys representing those mariners in administrative hearings (Spivey, 1997). Spivey discusses the circumstances under which crewmembers are required to be tested for dangerous drugs, the testing process, and the method by which the Coast Guard issues formal charges if the drug test result is positive. She also covers procedures in lieu of an administrative hearing such as voluntary deposit, or voluntary surrender in lieu of a hearing that relinquishes the Credential permanently. Finally, she discusses the administrative hearing process, the Administrative Law Judge's role, and appeal procedures. Although the procedural rules have changed in the last 15 years, this article is still an excellent primer on the suspension and revocation process involving crewmembers facing loss of their Credentials as the result of a positive chemical test for dangerous drugs.

This author also published an article addressing similar issues covered in the Spivey article but with new information based on regulatory changes and recent appeal decisions concerning the cure process (Brudzinski, 2010, April 13). The latter article places particular emphasis on the options available to mariners that test positive for dangerous drugs which enable them to have their Credentials returned. It addresses the hearing process but also details procedures for entering into and successfully completing the terms of a cure settlement agreement, an avenue chosen by most credentialed mariners/crewmembers that test positive. The suspension and revocation process allows for little discretion on the part of the Administrative Law Judge if the Judge finds the reason for the test is in accordance with 46 C.F.R. pt. 16 and the sample was tested in accordance with 49 C.F.R. pt. 40. If the chemical test is ordered in accordance with 46 C.F.R. pt. 16, a positive result creates the presumption that the crewmember is a user of dangerous drugs for which is the law mandates Revocation of the crewmember’s Credential (Brudzinski, 2011); 46 U.S.C. § 7704(c) (2006). The above articles provide a thorough overview of the Coast Guard’s suspension and revocation process involving credentialed mariners that test positive for dangerous drugs; however, the articles do not provide any empirical evidence that chemical testing discourages drug use, reduces the potential for casualties related to drug and alcohol use, and enhances the safety of maritime transportation.

C. DRUG TESTING'S LIMITATIONS

Rothstein (1991) claims there are several problems with drug testing from the standpoint of technology assessment: 1) misidentification can occur because drug tests detect metabolites rather than the drugs themselves (chemical tests under 49 C.F.R. pt. 40 detects both); 2) metabolites do not detect impairment (except through the blood immediately, then it shows in the urine); 3) the duration of detectability of drug metabolites in urine is limited; and, 4) there may be positives due to passive inhalation (however, the cut off levels in 49 C.F.R. pt. 40 are high enough to disprove this). Despite these limitations, one may infer people that test positive are more likely than those who test negative to come to work under the influence of drugs or take drugs during the workday. In general, Rothstein claims drug testing's goal was not clear and its effectiveness was unproven (Rothstein, 1991). These are all valid concerns and improvements over the last two decades have minimized many of them; however, federally-mandated chemical testing of commercial vessel personnel's goals are clear: 1) discourage drug and alcohol use among commercial vessel personnel; 2) reduce the potential for marine casualties related to drug and alcohol use; and, 3) enhance the safety of maritime transportation industry.

Drug testing's proponents claim improved productivity and safety with fewer drug related absences and accidents are being directly attributed to drug testing but even if these improvements resulted from drug testing, it is not clear that they would not have occurred in the absence of drug testing (Rothstein, 1991). Agreed, but "Coast Guard data do not specifically indentify the use of drugs or alcohol as a major causal effect in commercial vessel losses or casualty damage" (proposed, 53 Fed. Reg. Jul. 8, 1988, p.

25,927). Accordingly, this study does not examine the relationship between chemical testing and the number or frequency of accidents, personal injuries, or deaths because increases or decreases in injuries or deaths may be due to factors other than use of dangerous drugs. Reducing the potential for marine casualties related to drug and alcohol use does not require findings that drugs or alcohol caused the casualty.

A few years later, Comer (1994) claimed, among other things, that drug testing has not been shown to be associated with enhanced organizational productivity and safety. Comer cites Normand, Salyards, and Mahoney (1990) who studied applicants for postal service jobs in Washington, D.C. Those applicants tested positive for drugs but were hired for the purposes of data collection. The hired applicants had higher rates of absenteeism and involuntary turnover but there was no significant relationship between their Pre-Employment drug test results and their rate of injuries and accidents (Comer, 1994). These findings are similar to those in Parish (1989) concerning drug testing and job performance. Parish (1989) conducted a six month examination of 180 new employees at a large teaching hospital. Urine testing resulted in a 12% positivity rate. Parish (1989) found no significant differences between employees testing positive and those testing negative because the size of the drug-positive groups was not large enough to detect subtle differences in job performance or retention and that further study is needed. These findings seem to be consistent with the observations of Rothstein (1991) and Comer (1994). The Coast Guard did not attempt to claim chemical testing would improve job performance, productivity, or overall safety. It claimed chemical testing “should also reduce the potential for marine casualties related to drug and alcohol use” (proposed, 53 Fed. Reg. Jul. 8, 1988, p. 25,927). In its Final Rule, it expanded that statement to "reduce the potential for marine casualties related to drug and alcohol use, and enhance the safety of the maritime transportation industry" (53 Fed. Reg. Nov. 21, 1988, p. 47,064).

D. DISCOURAGING DRUG USE IN GENERAL

It makes sense that the first step any employer would take to discourage drug use would be to screen employment applicants for evidence of drug use.[11] To determine the effectiveness of drug screening applicants, Cabanilla, Frankenfield, Fudala, Lange, and Moler (1994) conducted a two month study in 1989 and again in 1991, screening applicants for employment at the Johns Hopkins Hospital in Baltimore, Maryland. Among other things, they found 10.8% of acceptable urine specimens tested positive for one or more drugs in 1989 versus 5.8% in 1991. They also found the decrease to be statistically significant ($p < 0.05$). The authors acknowledge that the rate of drug use within society had also decreased from 1989 to 1991; however, they claim the decrease in their study was more dramatic and appears to reflect other forces rendering it unlikely to be due to shifting drug use patterns within the community where their applicants were drawn.

Cabanilla et al. (1994) conclude the decrease in drug detection among applicants for employment was related, at least in part, to the existence of the urine testing program. The United States Coast Guard implemented chemical testing to discourage drug and alcohol use by commercial vessel personnel, reduce the potential for marine casualties related to drug and alcohol use, and enhance the safety of the maritime transportation industry. Similar to Cabanill et al. (1994) the study described herein examines the extent

[11] The terms "discourage" and "deter" are used interchangeably in this study.

to which chemical testing has discouraged drug and alcohol use by commercial vessel personnel. A good starting point to determine whether drug testing discourages drug use among commercial vessel crewmembers is the military. The military has been drug testing its personnel since 1981. Like chemical testing of commercial vessel personnel, the military imposes job loss on those who test positive and such high penalties are likely to yield the maximum deterrence (Mehay & Pacula, 1999).

Using 1995 data from the National Household Survey of Drug Abuse (NHSDA) and the Department of Defense's Worldwide Survey of Drug Abuse (DODWWS), Mehay and Pacula (1999) examined the deterrence effect by comparing differences in illicit drug use between the military and the civilian populations.[12] They found the military's strict anti-drug program to be highly effective in deterring illicit drug use to the extent drug participation in the military ranged between 4% and 16% lower than in the civilian sector, depending on the age group. They also used surveys based on self-reported data, which by their very nature may be subject to biases or underreporting.

Mehay and Pacula (1999) suggest costs savings and deterrence through lower random testing rates might be better achieved by returning to the "two-strikes policy" used in 1984 (allowing lower ranking members to remain in the service after a positive drug test) rather than terminating all personnel and replacing them as a result of one positive test[13] (Mehay & Pacula, 1999).

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[12] The National Household Survey on Drug Abuse (NHSDA) is now called the National Survey on Drug Use and Health (NSDUH). Source - http://www.oas.samhsa.gov/NSDUHlatest.htm.

[13] The survey questionnaire asks "if the military stopped random, unannounced drug testing, how likely do you think you would be to use drugs" but does not discuss the percentage breakdown in responses. DODWWS, (2008), Appendix J, p.16, question 94.

According to the 2008 DOD Survey of Health Related Behaviors Among Active Duty Military, self-reported dangerous drug use within the last 30 days in the military decreased from 27.6% in 1980 to 19.0% in 1982, 8.9% in 1985, 4.5% in 1988, 3.4% in 1992, 3.0% in 1995, 2.7% in 1998, and 3.4% in 2002. In 2005 and 2008 it increased to 5.0% and 12.0% respectively due in part to wording changes in the questionnaires; therefore, percentages from those years are not comparable to prior years (DOD Survey, 2008, Table 3.2.2). Self-reported heavy alcohol use (consuming five or more drinks on the same occasion at least once a week during the past 30 days) within the past month has remained at about the same level (20 to 21%), except between 1988 and 2005 when it fell to 15-18.5% (DOD Survey, 2008, Table 3.2.1; Executive Summary, p. 3).

Mehay and Pacula's (1999) concern about the cost of replacing terminated personnel is valid because commercial vessel personnel that test positive lose their jobs as well. If they are holders of Coast Guard issued Credentials, they also are subject to losing their Credentials through the suspension and revocation process; however, they may avail themselves of the opportunities for cure as detailed at 46 C.F.R. §§16.201(e) and (f) so they can return to work; and, if they are Credential holders, the additional requirements prescribed in their settlement agreements. The individual crewmember, however, must bear the cost of cure. Unlike Mehay and Pacula (1999), this study did not use surveys; instead, it used drug testing results reported to the Coast Guard by marine employers.

French, Roebuck, and Alexandre (2004) found, among other things, 47% of those surveyed worked for a company that had some type of drug testing program, the most popular of which was pre-employment testing (38.8%) followed by reasonable suspicion testing (30.6%), then random testing (24.2%). The study used data from the 1997 and 1998 National Household Surveys on Drug Abuse to examine the relationships among drug use and workplace drug testing programs for employed individuals between age 18 and 65. They found those programs achieved a desirable result by deterring some potential drug using employees but it often comes at a high cost in the form of drug testing expenses, employee turnover, and additional recruitment efforts, similar to the findings in the Mehay and Pacula (1999) study.

Mehay and Pacula (1999) as well as French et al. (2004) suggest drug testing seems to discourage drug use but questions whether the costs are worth it. The costs of chemical testing commercial vessel personnel (approximately $50 - $65 per test, depending on the type) are dispersed among individual commercial vessel personnel and their employers. These costs can be kept low by fewer positive Random tests which will result in overall Random testing at the 25% level instead of the 50% level. Fewer positive chemical tests will ordinarily result in a decreased need for additional chemical tests which necessarily drive up the costs. Further, less drug use will ordinarily result in fewer Reasonable Cause tests and fewer Post-Accident tests.

E. DISCOURAGING STUDENT DRUG USE

On the issue of simply discouraging drug use, studies pertaining to students are informative. James-Burdumy, Goesling, Deke, and Einspruch (2010) studied mandatory-random student drug testing (MRSDT). MRSDT's goal is to reduce substance use among students whose high school districts have applied for and received funds to implement mandatory-random drug testing. MRSDT requires students and their parents to sign consent forms agreeing that participation in sports or other school activities will be conditioned upon the students being subject to random drug testing. Like commercial vessel personnel chemical testing, the MRSDT program administers drug tests to at least 50% of eligible students to detect the presence of at least five substances (marijuana, amphetamines, cocaine, methamphetamines, and opiates). MRSDT also uses questionnaires concerning alcohol use.

The MRSDT program's theory predicts mandatory, random student drug testing may reduce students' use of substances. If students are aware a random drug test is possible they might stop using substances or at least give them a reason to refuse to use substances. The program also predicted students testing positive for drugs can be identified and referred for treatment or counseling. Finally, the MRSDT program predicted it would most likely have a "spillover" effect on other students as they observe and are influenced by their peers' behavior.

James-Burdumy et al. (2010) compared students in treatment schools with MRSDT to students in control schools without MRSDT. Among other things, the study discovered that within the preceding thirty days, 16% of students subject to MRSDT reported using any substance compared with 22 % of comparable students in the control schools without MRSDT. It also found 10 % of students subject to MRSDT reported using any substance excluding alcohol within the preceding thirty days compared to 13% of comparable students in the control schools without MRSDT. Further, it found testing for a larger number of substances as well as testing for alcohol and tobacco were significantly correlated with lower substance use in the treatment schools relative to the control schools. Out of 3,476 random drug tests administered in MRSDT schools during the year long, 2007-2008 evaluation period, 38 were positive, resulting in a drug test positive rate of 1.09%. The study also found a decline in student drug use over the last 10 years. This study of commercial vessel personnel shows similar results from archived drug testing results, not from questionnaires. For example, the Random positive test rate for commercial vessel personnel during 2007-2008 averaged 1.15%, close to the MRST positive rate of 1.09%. MRST students and commercial vessel crewmembers were aware that they were subject to unannounced random drug testing.

The MRST study found no “spillover effect” from experimental schools to control schools and no impact on the number of disciplinary incidents. Like the MRSDT program’s theory that drug testing reduces student substance use in part by deterrence through the threat of testing, this study shows mandatory chemical testing of commercial vessel personnel coincides with reduced substance use, including alcohol.

There are two other studies pertaining to student drug testing that have relevance to discouraging drug use by commercial vessel personnel. The first study is by Yamaguchi, Johnston, and O’Malley (2003a). The authors used questionnaires and focused on grades 8, 10, and 12. Among other research questions, Yamaguchi et al., 2003a, p. 159 asked: “What relationship exists between student drug use and school testing?” The investigators found no association between drug testing and the prevalence or frequency of student drug use (Yamaguchi et al., 2003a).

The same authors conducted a subsequent study, referred to as Yamagouchi et al., (2003b). Their second study found drug testing does not inhibit student drug use but random testing of all students was the most promising in reducing student drug use. It also found testing of athletes did not produce encouraging results (Yamagouchi et al. 2003b). Consistent with these findings, the study of commercial vessel crewmembers shows, among other things, that gradually decreasing Random drug test positivity rates are an accurate predictor of gradually decreasing Post-Accident positivity rates.

F. DRUG TESTING AND ACCIDENTS

In the construction industry, with its high rates of alcohol and other drug use coupled with the high-risk, safety-sensitive nature of the work, Gerber and Yacoubian (2001) found that between 1988 and 1998, the average company in its questionnaire sample that tested for drugs reduced its injury rate 51% within two years of implementing drug testing. The sample's injury rate went from 8.9 injuries per 200,000 work-hours to 4.4 injuries per 200,000 work-hours, which was statistically significant (Gerber & Yacoubian, 2001).

Even if the improvements noted in the Gerber and Yacoubian (2001) study resulted from drug testing, they could have taken place in the absence of drug testing (Rothstein, 1991). The same can be said for vessel casualties, injuries, and deaths. Crewmember injuries and deaths as well as vessel losses and damages may be higher or lower but the reasons may not necessarily be due to chemical testing or the absence of chemical testing. For example, from 1992 through 2010, there were 2,072 fishing vessels lost at sea and 1,055 fishing vessel fatalities. The fishing vessel losses averaged 109 per year but from 2006 through 2010, the average loss rate dropped to 61 per year. The fatalities averaged 56 per year but from 2006 through 2010, the average dropped to 39 per year (U.S. Coast Guard, 2011). Most losses are due to flooding and fires - problems that are largely not covered nor can be substantially prevented by the current regulations.

The reductions in fishing vessel losses and fatalities cannot be attributed to Pre-Employment, Random, or Reasonable-Cause drug testing because commercial fishing vessel crewmembers are not subject to those comprehensive chemical tests except for Post-Accident drug and alcohol tests. In the case of crewmembers on other vessels subject to comprehensive chemical testing, the potential for marine casualties related to drugs or alcohol may decrease but it does not necessarily mean that the potential for marine casualties related to non-drug or non-alcohol factors will also decrease. Put another way, while the number of vessel casualties related to drugs and alcohol decreases, the number of vessel casualties related to other factors may increase.

Jacobson (2003) found from 1988 through 1990, drug testing led to a 9 to 10 percent reduction in truck accident fatalities but she does not “reject at the 5 percent level the hypothesis that there has been no change in trends in fatal truck crashes relative to car crashes per VMT [vehicle miles traveled] in 1998, 1989, or 1990” (Jacobson, 2003, p.139). Put another way, the reduction in truck accident fatalities may not necessarily be attributed to drug testing compared to car crash fatalities per vehicle miles traveled. The Jacobson study illustrates the limitations in attempting to link drug testing with improved safety statistics. Relating the Jacobson study to chemical testing of commercial vessel personnel, marine casualty data might show vessels with crewmembers not subject to chemical testing other than Post-Accident drug and alcohol testing have a higher death rate per serious marine incident than vessels with crewmembers previously subject to Random drug testing. To claim chemical testing reduces the number of deaths per serious marine incident would ignore the multitude of other causative factors such as crew training and certification, material condition of the vessel, the relative danger of the vessel’s work, duration and conditions of deployment, and crew fatigue, just to name a few. Because of those limitations, this study addressed only the goals of commercial vessel personnel chemical testing as expressed in the Final Rule and avoided any comparisons of death or injury rates.

Normand et al. (1990) investigated the relationship between pre-employment drug-test results and absenteeism, turnover, injury, and accidents of U.S. Postal Service employees. Among other things, the Normand study found the positive drug-test group had a 59.3% higher absence rate and a 47% higher involuntary separation rate than those who tested negative. However, Normand et al. (1990) found no statistically significant relationship between drug-test results and the number of injuries and no statistically significant relationship between drug-test results and the number of accidents. The study explained that various factors may have contributed to the non-significant findings such as the relatively short amount of time new employees were studied and the relatively low numbers of employees. “As the tenure of participants increases, the accident and injury rates are expected to increase, which will permit us to more efficiently detect any true differences” (Normand et al., 1990, p. 637).

Zwerling, Ryan, and Orav (1990) conducted pre-employment drug screening of U.S. Postal Service employees that were hired and found those testing positive for marijuana had increased risks of termination, accident, injuries, and discipline compared to those testing negative. More specifically, Zwerling et al. (1990) found those testing positive for marijuana have 55% more industrial accidents, 85% more injuries, and a 78% increase in absenteeism. Zwerling et al. (1990) also found those testing positive for cocaine had no increased risk for termination but did have an increased risk for accidents, injuries, and disciplinary actions relative to those testing negative; however, only the risk for injuries was statistically significant for those testing positive for cocaine. Those testing positive for cocaine had a 145% increase in absenteeism and also an 85% increase in injuries (Zwerling et al., 1990).

In their second Post Office study, Ryan, Zwerling, and Jones (1992) found those that tested positive for marijuana and cocaine had increased risks for firing, accidents, injuries, discipline, and absence. Ryan et al. (1992) specifically found marijuana users had a statically significant increased risk of accident and injury and that cocaine users had a statistically significant increased risk of accident but just short of a statistically significant risk for injury (p = .051).

Consistent with Normand et al. (1990) and somewhat at odds with Zwerling et al. (1990) and Ryan et al. (1992) is Parish (1989). Parish assessed the relationship between positive drug tests and job performance. He compared job performance characteristics of employees testing positive with those employees testing negative and found "no significant difference between individuals who tested positive and those who tested negative using broad categories of job performance" (Parish, 1989, p. 47).

The instant study on commercial vessel crewmembers focused on Random and Post-Accident positivity rates with the latter category including injuries and accidents. It did not address job performance because prospective crewmembers that failed the Pre-Employment drug test must be denied employment as a crewmember; therefore, this study could not measure employment outcomes based on the Pre-Employment drug test. Moreover, employed crewmembers failing a Random, Reasonable Cause, Periodic, or Post-Accident drug test must also be removed from duties which directly affect the safe operation of the vessel as soon as practicable, so conducting a study of crewmembers like

Normand et al. (1990) and Zwerling et al. (1990) was not possible for commercial vessel crewmembers.

Fortner, Martin, Esen, and Shelton, (2011) surveyed 1,058 human resource professionals whose companies had drug testing programs. The participants responded from a sample of 6,000 randomly selected from the Society of Human Resource Management's 600,000 members. The human resource professionals answered multiple choice questions the Drug and Alcohol Testing Industry Association developed to obtain their current opinions about drug testing. They reported a decrease in workers' compensation incidence rates from 14% to 6% after implementing drug testing programs, a decrease of 57%. Fortner et al. (2011) also found workers' compensation premiums were lower for companies having mandatory drug testing because it is known drug testing will decrease accidents and costs associated with claims. Most relevant to this study, Fortner et al. (2011) found Random testing to be the greatest on the job drug abuse deterrent because employees do not know when they will be asked to provide a specimen. The instant study showed similar results; that is, crewmembers not knowing when the Random test will occur will be a great deterrent to drug use.

The Fortner et al. (2011) results are consistent with Levine and Rennie (2004). Levine and Rennie (2004) found that to truly focus on drug detection, Random drug testing is better than Pre-Employment drug testing. Pre-Employment drug testing encourages employees to simply pass a one-time drug test which will only detect "the uninformed, forgetful, or most severely addicted individuals" (Levine and Rennie, 2004, p 323). The Fortner study does not indicate whether the human resource respondents also relied upon drug testing results to support their answers. This study did not use questionnaires but instead used drug and alcohol testing results submitted to the Coast Guard by marine employers as required by regulation. This eliminated subjective responses from crewmembers and their employers and allowed inferences and conclusions to come from the data, not the opinions of crewmembers or their employers.

G. DRUG TESTING RESULTS

The federal government's primary contractor for safety-sensitive drug testing is Quest Diagnostics. Quest's Drug Testing Index Archives provide an abundance of drug testing results going back to 1988, and, for federally-mandated, safety-sensitive drug testing results, back to 2007. Since 1988, the annual positivity rates for the combined U.S. Workforce have gradually dropped from a high of 13.6% in 1988 to a low of 3.5% in 2011. The 2003-2011 rates are shown below:

Table 1

Quest Drug Testing Index: Combined U.S. workforce 2003-2011

Year	Rate
2003	4.5%
2004	4.5%
2005	4.1%
2006	3.8%
2007	3.8%
2008	3.6%
2009	3.6%
2010	3.5%
2011	3.5%

In 2007, Quest started collecting positivity rates for federally-mandated safety-sensitive workers. Those rates, compared to others, are shown below:

Table 2

Quest Drug Testing Index: Federally-mandated safety-sensitive workers

Year	Rate
2007	1.8%
2008	1.6%
2009	1.5%
2010	1.5%
2011	1.7%

Table 3

Quest Drug Testing Index: General U.S. workforce

Year	Rate
2007	5.7%
2008	5.3%
2009	5.4%
2010	5.3%
2011	5.2%

Table 4

Quest Drug Testing Index: Federally-mandated safety-sensitive workers

Year	Rate
2007	1.6%
2008	1.4%
2009	1.4%
2010	1.4%
2011	1.5%

Table 5

Quest Drug Testing Index: U.S. general workforce

Year	Rate
2007	5.8%
2008	5.6%
2009	5.3%
2010	5.3%
011	5.3%

The Quest data shows a general downward trend in positivity rates. This study's findings are consistent with Quest's results but go further and compare the trends to show the extent to which chemical testing has discouraged drug and alcohol use by commercial vessel personnel, reduced the potential for marine casualties related to drug and alcohol use, and enhanced the safety of the maritime transportation industry.

III. METHODOLOGY

A. OVERVIEW

The methodology used in this study was a secondary data analysis of archived, Management Information System (MIS) chemical testing reports and archived, Serious Marine Incident (SMI) reports including chemical testing supplements, from 2003 through 2011. SMI reports and supplements are contained in the Marine Information Safety and Law Enforcement (MISLE) system. In 2003, the Coast Guard implemented the MISLE system. Among other things, MISLE has made vessel casualty and supplemental Post-Accident drug and alcohol testing information more readily available and retrievable than previous systems. Readily available and retrievable data is the reason this study focuses on the 2003-2011 timeframe. That timeframe is a sufficiently long and recent enough period from which to draw conclusions about the Coast Guard's chemical testing program.

B. DATA COLLECTION MEASURES/PROCEDURES

A data archive of drug and alcohol test results marine employers are required to submit to the Coast Guard was analyzed for this study. This author obtained these data archives through requests to the U.S. Coast Guard at efoia@uscg.mil under the Freedom of Information Act (FOIA), 5 U.S.C. § 552 (2006); 6 C.F.R. Part 5 (2012).[14] The requests described this academic study and asked for Marine Information System Pre-Employment, Random, Reasonable Cause, and Post-Accident drug testing results from 2003-2011 that marine employers send to the Coast Guard on a yearly basis.

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[14] See http://www.dhs.gov/xfoia/Copy_of_editorial_0318.shtm.

The FOIA request also asked for the yearly 2003-2011 listing of serious marine incident reports for commercial fishing vessels and small passenger vessels together with Post-Accident drug or alcohol test results. After the initial request, this author was able to maintain contact with the appropriate official most knowledgeable of the data available and was therefore able to further refine the requests. The listed reports contain the number of drug or alcohol tests initiated and the results of those tests. For drug test results, it asked only for the number of verified positives for one or more drugs. For alcohol tests, it asked only for the number of tests and whether the tests were positive. The SMI data were made available in EXCEL® Spreadsheet form and contain no names or other personal identifying information.

The MIS drug testing results were provided in Microsoft Word form and entered into EXCEL® spreadsheets. All types of drug tests and corresponding results are displayed on a form similar to the form marine employers submit to the Coast Guard on a yearly basis. The employers' yearly reports are compiled and maintained at Coast Guard Headquarters. This study did not require names or other personal identifying information as part of the data requested. The author asked for and was granted a FOIA fees waiver in accordance with 6 C.F.R. § 5.11(d) (4) and (5) (2012) because this is an academic study.

C. DATABASES

The MIS database consists of the following chemical test results from all commercial vessel crewmembers subject to chemical testing for the following types of drug tests: Pre-Employment, Random, Post-Accident, Reasonable Cause, Return-to-Duty, and Follow-up. For each type of chemical test, marine employers list the results on the

U.S. Department of Transportation Drug and Alcohol Testing Management Information System (MIS) Data Collection Form in thirteen (13) numbered columns as follows: 1) total number of test results; 2) verified negative; 3) verified positive results for one or more drugs; 4) positive for marijuana; 5) positive for cocaine; 6) positive for PCP; 7) positive for opiates; 8) positive for amphetamines; 9) adulterated; 10) substituted; 11) shy bladder with no medical explanation; 12) other refusals to submit to testing; and, 13) cancelled results. The totals in columns 1, 2, 3, 9, 10, 11, and 12 comprise the total number of test results for each type of test. Cancelled results are not included in the total number of test results. Positive results for the presence of specific drugs such as marijuana, cocaine, etc., are subsumed in column 3, titled "verified positive results for one or more drugs." Crewmembers' names or other identifying information are not included in the MIS data collection forms.

The SMI data base in the MISLE system consists of all vessel casualty reports meeting the requirements of Serious Marine Incident as described earlier in this proposal under the headings "Required Testing" as well as "Records and Reports." Marine employers submit those reports to the Coast Guard on form CG-2692, "Report of Marine Accident, Injury or Death" together with a supplemental form entitled "Required Chemical Drug and Alcohol Testing Following a Serious Marine Incident," form CG-2692B, as described in 46 C.F.R. §§ 4.05-10, 4.06-60, and 16.240 (2012).

The numerical relationship of serious marine incidents to all marine casualties is displayed in Table 6 on the following page.

Table 6

Serious marine incidents compared to all marine casualties

CG Marine Casualty Investigations, 2003 – 2011			
Calendar Year	**Not a Serious Marine Incident**	**Serious Marine Incident**	**All Marine Casualty Investigations**
2003	3,471	594	**4,065**
2004	3,050	827	**3,877**
2005	3,026	868	**3,894**
2006	3,635	961	**4,596**
2007	3,905	791	**4,696**
2008	4,067	702	**4,769**
2009	3,816	662	**4,478**
2010	4,557	717	**5,274**
2011	5,136	788	**5,924**
	34,663	**6,910**	**41,573**

D. POPULATION AND SAMPLE

There are two populations of crewmembers. One population consists of crewmembers subject to chemical testing and the other population consists of crewmembers not subject to chemical testing except for Post-Accident drug and alcohol tests. Both populations are subject to Post-Accident chemical testing. This study compares the Post-Accident chemical testing positivity results for drugs and alcohol between the two populations. It also compares the number of Post-Accident, positive drug and alcohol tests per serious marine incident in which drug and alcohol tests are ordered between both populations. Finally, this study compares the Random and Post-Accident positivity rates of all crewmembers subject to chemical testing to show that the Random drug test is a good predictor of Post-Accident positivity rates.

Samples from the population subject to chemical testing consist of yearly 2003-2011 Post-Accident drug and alcohol test results from the SMI database as well as the number of serious marine incidents involving one vessel category. Samples from the population subject to chemical testing also consist of yearly 2003-2011 Pre-Employment, Random, and Post-Accident chemical drug test results from the MIS database. In addition to all crewmembers subject to chemical testing from the MIS database, serious marine incidents and Post-Accident positivity rates from crewmembers of U.S. Documented vessels of 100 gross tons or less certificated for carrying six or more passengers for hire were examined.

Samples from the population not subject to comprehensive chemical testing (Pre-Employment, Random, etc.) consist of drug and alcohol tests and the number of serious marine accidents in the SMI database from crewmembers of U.S. Documented commercial fishing vessels.

The 100 tons or less vessels are more fully described in Subchapters T and K of Title 46 Code of Federal Regulations (C.F.R.) and are hereinafter referred to as small passenger vessels or SPVs. Small passenger vessel crewmembers in safety sensitive positions are subject to chemical testing as well as Coast Guard credentialing or licensing requirements. SPVs are also subject to Coast Guard inspection and are the most regulated of all U.S. Documented vessels. They are required to be manned with a minimum number of credentialed crewmembers in certain positions that are subject to watch standing limitations. The vessel's Certificate of Inspection shows it has met the minimum Coast Guard safety standards for fire-extinguishing systems, manning, vessel de-watering capabilities, life saving, and navigation equipment. The Certificate of

Inspection also prescribes the maximum number of passengers the vessel may carry. It is displayed in an area accessible to passengers.

U.S. Documented commercial fishing vessels (hereinafter referred to as commercial fishing vessels, CFVs, or fishing vessels) are the least regulated of all U.S. Documented commercial vessels and are not subject to Coast Guard inspection except for some safety features.[15] Commercial fishing vessel crewmembers are not subject to Coast Guard credentialing or licensing requirements; they have no limits on the time they are on duty standing watch; and, they are not required to pass a Pre-Employment chemical test or be subject to subsequent Random or Reasonable Cause testing.[16] They are, however, subject to Post-Accident drug and alcohol testing so they present a perfect contrast to small passenger vessel crewmembers for comparison.[17]

Table 7 shows the yearly 2003-2009 selected vessel populations of active U.S. Documented commercial fishing vessels compared to the population of active U.S. Documented small passenger vessels.

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[15] 46 C.F.R. § 16.240 (2012); 49 C.F.R. Part 40, Appendix H (2012). Alcohol testing results are submitted to the Coast Guard only as part of the Serious Marine Incident Report under 46 C.F.R. § 4.06, not as part of the MIS data collection form in accordance with 46 C.F.R. § 16.500(a) (2012).

[16] This study refers to Pre-Employment, Random, and Reasonable Cause testing as comprehensive chemical testing.

[17] Commercial fishing vessels 200 gross tons and above require a licensed master thus subjecting crewmembers in safety sensitive positions to comprehensive drug testing in addition to Post-Accident testing. The MIS data base may therefore include some Post-Accident drug test results from commercial fishing vessels 200 gross tons and above which are also included in the second SMI sample. The number of such vessels is relatively small and will not affect the differences in Post-Accident positivity rates between the MIS and SMI second samples because the positivity rates are reported to the SMI database as well as the MIS database.

Table 7

Populations of commercial fishing vessels compared to small passenger vessels

Selected Vessel Populations		
Calendar Year	**Commercial Fishing Vessels (Documented by USCG)**	**Small Passenger Vessels (T&K)**
2003	24,005	6,007
2004	23,528	5,980
2005	22,782	5,709
2006	21,983	5,640
2007	21,584	5,637
2008	21,002	5,784
2009	20,503	5,740
2010	20,060	5,723
2011	19,791	5,680
Selection Criteria	**[Commercial Fishing Vessel] [In Service] [VALID Document]**	**[Passenger] [Under 100 GT] [In Service] [Inspected]**

E. OPERATIONAL DEFINITIONS OF VARIABLES

For Hypotheses 1A and 1B, the independent or predictor variable is the type of crewmember measured on a nominal scale comparing two levels: 1) commercial fishing vessel crewmembers not subject to chemical testing except for Post-Accident drug and alcohol tests; and, 2) small passenger vessel crewmembers subject to chemical testing.

The dependent variable for Hypothesis 1A is the yearly (SMI) Post-Accident drug test positivity rates for one or more drugs. The criterion variable was measured using a ratio scale to determine positivity rates. The (SMI) Post-Accident yearly drug test positivity rates from commercial fishing vessel crewmembers not otherwise subject to chemical testing were determined by dividing the total number of verified positive Post-Accident drug test results for one or more drugs each year by the total number of Post-Accident drug tests administered to commercial fishing vessel crewmembers for that year. The SMI Post-Accident yearly drug test positivity rates from small passenger vessel crewmembers were determined by dividing the total number of verified positive (SMI) Post-Accident drug test results each year by the total number of (SMI) Post-Accident drug tests administered to small passenger vessel crewmembers for that year.

A positive drug test means the test was conducted in accordance with 49 C.F.R. pts. 4, 16, and 40 and was reported as "positive" by a Medical Review Officer because the test indicated a presence of a dangerous drug or drug metabolite equal to or exceeding the cutoff concentrations established in 49 C.F.R. § 40.87 (2012), as shown in Table 8.

Table 8

Initial and confirmatory drug test cutoff values

Initial test analyte	Initial test cutoff concentration	Confirmatory test analyte	Confirmatory test cutoff concentration
Marijuana metabolites	50 ng/mL	THCA	15 ng/mL.
Cocaine metabolites	150 ng/mL	Benzoylecgonine	100 ng/mL.
Opiate metabolites			
Codeine/Morphine	2000 ng/mL	Codeine	2000 ng/mL.
		Morphine	2000 ng/mL.
6–Acetylmorphine	10 ng/mL	6–Acetylmorphine	10 ng/mL.
Phencyclidine	25 ng/mL	Phencyclidine	25 ng/mL.
Amphetamines			
AMP/MAMP	500 ng/mL	Amphetamine	250 ng/mL.
		Methamphetamine	250 ng/mL.
MDMA	500 ng/mL	MDMA	250 ng/mL.
		MDA	250 ng/mL.
		MDEA	250 ng/mL

Source: 65 Fed. Reg. 79,526 (Dec. 19, 2000), as amended by 75 Fed. Reg. 49,862 (Aug. 16, 2010) codified at 49 C.F.R. § 40.87 (footnotes omitted).

Federal Regulations include very specific procedures to prevent the possibility of false positive drug tests. Those procedures include: 1) using certified laboratories subject to inspection and audit; 2) validating all results by a Medical Review Officer (MRO) for each positive determination; and, 3) having pre-defined thresholds for positive test determinations. Given these tight controls, the positive drug test results used in this study are considered to include few errors.[18]

The dependent variable for Hypothesis 1B is the same as for Hypotheses 1A except it compares the yearly (SMI) Post-Accident alcohol test positivity rates instead of drug test positivity rates. A positive test for the presence of alcohol means evidence of alcohol to the extent of 0.02 or higher as provided in 49 C.F.R. §§ 40.3 and 40.23.[19]

For Hypotheses 1C, the independent or predictor variable is the same as for Hypothesis 1A and 1B except this variable is measured using a nominal scale comparing two levels: 1) crewmembers on commercial fishing vessels not subject to chemical testing except for Post-Accident drug and alcohol tests; and, 2) crewmembers on ALL vessels subject to chemical testing.

The dependent or criterion variable for Hypothesis 1C is the yearly Post-Accident drug test rates for one or more drugs. This study measured the criterion variable using a ratio scale to determine positivity rates. The (SMI) Post-Accident yearly drug test

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[18] Prior to October 1, 2010, the cocaine metabolite initial test cutoff concentration was 300 ng/ml vice 150 ng/ml. Also, the amphetamine initial test cutoff was 1000 ng/ml vice 500 ng/ml and the confirmatory test cutoff was 500 ng/ml vice 250 ng/ml. For methamphetamine, the old confirmation test cutoff was 500 ng/ml vice 250 ng/ml. These lower cutoffs will likely produce an increase in the number of positive cocaine and amphetamine drug tests which will result in an “uptick” in positivity rates starting in 2011.

[19] The regulations at 49 C.F.R. § 40.23(c) (2012) require the employer that receives an alcohol test result of 0.04 or higher to remove immediately the employee involved in the accident from performing safety-sensitive functions. If the employer receives an alcohol test result of 0.02 – 0.39, the employer must temporarily remove the employee involved from performing safety sensitive functions.

positivity rates from commercial fishing vessel crewmembers not otherwise subject to chemical testing were determined by dividing the total number of verified positive Post-Accident drug test results for one or more drugs each year by the total number of Post-Accident drug tests administered to commercial fishing vessel crewmembers for that year. The MIS Post-Accident yearly drug test positivity rates from all vessels with crewmembers subject to chemical testing were determined by dividing the total number of verified positive Post-Accident drug test results each year by the total number of Post-Accident drug tests administered.

For Hypotheses 2A and 2B, the independent or predictor variable was the same as for Hypotheses 1A and 1B; that is, the type of crewmember. This variable is measured using a nominal scale comparing two levels: 1) crewmembers on commercial fishing vessels not subject to chemical testing except for Post-Accident drug and alcohol tests; and, 2) crewmembers on small passenger vessels subject to chemical testing.

The dependent or criterion variable for Hypothesis 2A is yearly (SMI) Post-Accident positive drug tests for one or more drugs per serous marine incident in which drug tests were reported. The criterion variable was measured using a ratio scale to determine positive tests per serious marine incident. The (SMI) Post-Accident yearly positive drug tests per serious marine incident from commercial fishing vessel crewmembers were determined by dividing the yearly number of positive drug tests by the yearly number of commercial fishing vessel serious marine incidents in which drug tests were reported.

The dependent or criterion variable for Hypothesis 2B is the yearly (SMI) Post-Accident positive alcohol tests per serous marine incident in which alcohol tests were reported. This study measured the criterion variable using a ratio scale to determine positive tests per serious marine incident. The (SMI) Post-Accident yearly positive alcohol tests per serious marine incident from commercial fishing vessel crewmembers were determined by dividing the yearly number of positive alcohol tests by the yearly number of commercial fishing vessel serious marine incidents in which alcohol tests were reported.

For Hypothesis 3, the Predictor Variable is the type of drug test. This variable was measured using a nominal scale comparing two levels: 1) Random drug tests of all crewmembers subject to chemical testing; and 2) Post-Accident drug tests of all crewmembers subject to chemical testing.

The dependent or criterion variable is the Random and Post-Accident yearly positivity rates for one or more drugs using a ratio scale to determine positivity rates. The (MIS) Random drug test positivity rates from all vessels with crewmembers subject to chemical testing were determined by taking the yearly number of verified positives for one or more drugs plus the number of Random drug test refusals which includes adulterated, substituted, "shy bladder" with no medical explanation, and other refusals to submit to drug testing, and dividing the sum by the total number of Random drug test results reported for that year. The Coast Guard used this method to determine Random positivity rates. The (MIS) Post-Accident drug test positivity rates from all vessels with crewmembers subject to chemical testing were determined by taking the yearly number of verified positives for one or more drugs and dividing it by the total number of Post-Accident tests reported for that year.

IV. ANALYSIS

Hypotheses 1A and 1B addressed comparisons between yearly and total 2003-2011 Post-Accident drug and alcohol positivity rates of commercial fishing vessel crewmembers and small passenger vessel crewmembers. Hypothesis 1C addressed comparisons between yearly and total 2003-2011 Post-Accident drug test positivity rates of commercial fishing vessel crewmembers and all crewmembers subject to chemical testing from all vessels. Hypotheses 2A and 2B addressed comparisons between yearly and total 2003-2011 ratios of positive Post-Accident drug and alcohol tests per serious marine incident in which drug and alcohol tests were reported of commercial fishing vessel crewmembers and small passenger vessel crewmembers. For Hypothesis 3, this author examined the relationship between Random and Post-Accident drug test results from crewmembers of all vessels to determine how strongly they are correlated and if Random positivity rates are a good predictor of Post-Accident positivity rates.

In comparing positivity rates and ratios of positive tests per serious marine incident in Hypotheses 1A, 1B, 1C, 2A, and 2B, this author employed tables and histograms. To determine if the differences in positivity rates and differences in ratios of positive tests per serious marine incident were statistically significant, this author used the two proportion *z*-test for those hypotheses. This author applied that test to compare the yearly and total differences in positivity rates and positive tests per serious marine incident between two relevant populations, one with crewmembers subject to chemical testing and one not subject to chemical testing except for Post-Accident drug and alcohol testing.[20]

Utilizing the two proportion *z*-test was based on the following assumptions: 1) the samples are categorical and independent; 2) crewmembers selected for drug and alcohol tests are selected as the result of a serious marine incident which is a random occurrence; 3) the test results are either positive or negative; 4) the predictor variable has two levels measured on a nominal scale – crewmembers subject to chemical testing and crewmembers not subject to chemical testing; 5) the number of tests in the samples is large - thirty and above; and, 6) ratio scale is used to determine positivity rates and positive tests per serious marine incident. The two proportion *z* test can also be used to examine each year individually.

In comparing Random and Post-Accident positivity rates in Hypothesis 3, I used the correlation coefficient and linear regression analysis to determine if there is a relationship between Random and Post-Accident positivity rates from all vessels with crewmembers subject to chemical testing. For all hypotheses, except Hypothesis 3, the null hypothesis would be zero; that is, there is no difference between the population proportions. For Hypotheses 1A and 1B, the alternative Hypotheses is commercial fishing vessel crewmember positivity population proportion is greater than the small passenger vessel crewmember proportion. For Hypotheses 1C, the alternative Hypothesis that the commercial fishing vessel crewmember population proportion is greater than the crewmember population proportion of all vessels subject to chemical

[20] "Subject to chemical testing" means subject to the prescriptions in 46 C.F.R. pt. 16; that is, subject to Pre-employment, Random, and Periodic as well as Post-Accident.

testing. For Hypotheses 2A and 2B, the alternative Hypotheses is commercial fishing vessel population proportions are greater than the small passenger vessel proportions. For Hypothesis 3, the null hypothesis is that there is no correlation. The alternative Hypothesis is there is a strong correlation between the two population proportions. For statistical tests in Hypotheses 1A, 1B, 1C, 2A, and 2B, the alpha level was set *a priori* at .05.

Rumsey (2011, pp. 240-42) explains the two-proportion *z*-test in easy to understand terms as does Larson and Farber (2009, pp. 407, 425) and Moore, McCabe, and Craig (2009, pp. 512-16). Simple explanations are also found under Statistical Hypothesis Testing, Common Test Statistics at wikipedia.org and at stattrek.com under Hypothesis Test: Difference Between Proportions. The two proportion *z* test formula is as follows:

$$z = \frac{(p_1 - p_2)}{\sqrt{p(1 - p)(1/n_1 + 1/n_2)}}$$

This formula compares differences in positivity rates (numerator) to the overall, or pooled, variation of the test results (denominator). The values p_1 and p_2 represent positivity rates in Hypotheses 1A, 1B, and 1C and ratios of positive tests per serious marine incident in Hypotheses 2A and 2B. For Hypotheses 1A, 1B, and 1C, those values are obtained by dividing the yearly, 2003-2011 Post-Accident positive drug or alcohol tests by the yearly number of tests administered for each variable. For Hypotheses 2A and 2B, those values are obtained by dividing the yearly 2003-2011 Post-Accident positive drug or alcohol tests by the yearly 2003-2011 number of serious marine incidents in which drug or alcohol tests were conducted for each variable.

For Hypotheses 1A, 1B, and 1C, the letter *p* represents the sum of Post-Accident positive drug or alcohol tests from each variable each year divided by the sum of Post-Accident drug or alcohol tests administered from each variable. For Hypotheses 2A and 2B, the letter *p* represents the sum of Post-Accident positive drug or alcohol tests from each variable each year divided by the sum of serious marine incidents each year from each variable in which drug or alcohol tests were reported.

For Hypotheses 1A, 1B, and 1C, the letter *n* represents the number of Post-Accident tests administered for each variable each year. In the case of determining the z test statistic or z score for all cumulative years, it is the total number of positive tests for all years divided by the total number of tests administered for Hypotheses 1A, 1B, and 1C. For Hypotheses 2A and 2B, it is the total number of positive tests divided by the total number of serious marine incidents. As shown in the tables, this study applies the two proportion *z*-test formula to the values each year as well as to the totals in order to arrive at the test statistic or *z* score for that year.

Hypothesis 3 examines the relationship between Post-Accident drug test positivity rates and Random drug test positivity rates from all vessels with crewmembers subject to chemical testing. This author tested Hypothesis 3 using linear regression and the correlation coefficient.

V. HYPOTHESIS 1A

In response to the first research question "[t]o what extent, if any, has chemical testing discouraged drug and alcohol use by commercial vessel personnel," recall that Hypothesis 1A states yearly 2003-2011 Post-Accident drug test positivity rates from small passenger vessel crewmembers subject to chemical testing are significantly lower than yearly 2003-2011 Post-Accident drug test positivity rates from commercial fishing vessel crewmembers not otherwise subject to chemical testing. The Null Hypothesis is there is no difference in the Post-Accident positivity rates between the two groups.

The yearly 2003-2011 Post-Accident drug tests, verified positives, and resulting positivity rates for commercial fishing vessels and small passenger vessels are displayed in Table 9 below.

Table 9

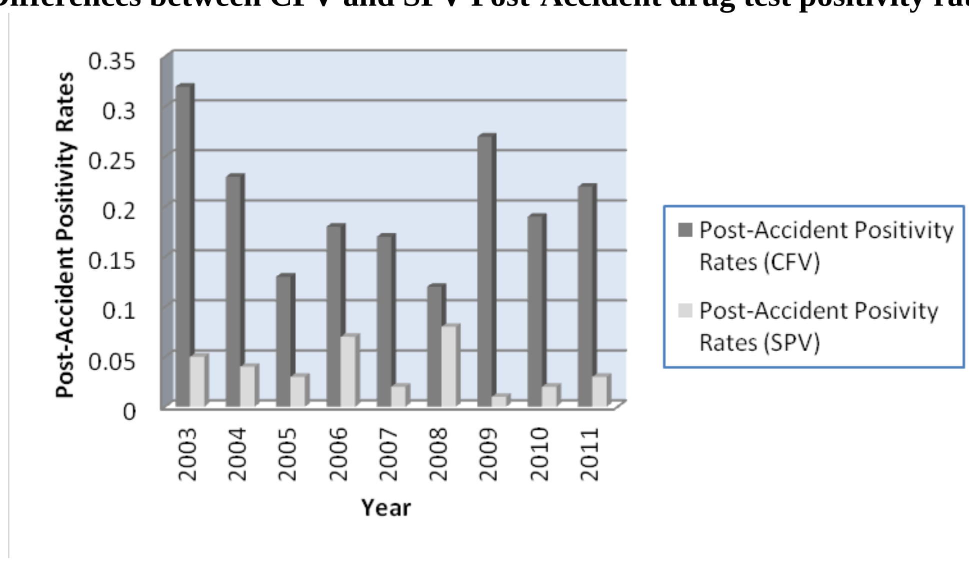
CFV and SPV Post-Accident drug tests and results

	Commercial Fishing Vessels (CFV)			Small Passenger Vessels (SPV)		
Year	Drug Tests	Positives	Rate	Drug Tests	Positives	Rate
2003	68	22	0.3235	64	3	0.0469
2004	82	19	0.2317	142	6	0.0426
2005	110	14	0.1274	107	3	0.0280
2006	160	28	0.1750	123	9	0.0732
2007	136	23	0.1691	122	3	0.0246
2008	100	12	0.1200	98	8	0.0818
2009	97	26	0.2680	84	1	0.0119
2010	73	14	0.1918	129	2	0.0155
2011	88	19	0.2159	152	4	0.0263
Mean			0.2025			0.0389
STDEV			0.0656			0.0246

Table 9 shows a decrease in positivity rates with occasional upward positivity spikes in both categories. A variety of factors could change the year after year positivity rates. For example, the 2011 increase may be attributed in part to lower initial and confirmatory test cutoff values; however, it is too early to see if the lower cutoff values show a trend with only one year's data. It will be necessary to collect a few more years of data to confirm a trend. There may be many other reasons for variations in the positivity rates within each category. The smaller the number of tests and corresponding results, the greater the likelihood of dramatic percentage changes in positivity for any given year. A small number of tests also may be attributed to crewmembers being unavailable for testing because they and their fishing vessels were lost at sea. The differences in positivity rates from one year to the next may vary greatly in both vessel categories but the 2003-2011 positivity rates of commercial fishing vessels are always higher than the positivity rates of small passenger vessels as shown in Figure 1 below.

Figure 1

Differences between CFV and SPV Post-Accident drug test positivity rates



As shown in Table 10, Post-Accident drug test positivity rates of SPVs with crewmembers subject to chemical testing are significantly lower than drug test positivity rates of CFVs with crewmembers not otherwise subject to chemical testing. Table 10 shows Post-Accident drug test positivity rates of SPV crewmembers at least 32% lower (2008) and as much as 96% lower (2009) than Post-Accident drug test positivity rates of CFV crewmembers. Small passenger vessel crewmembers had an average of 77% fewer Post-Accident positive drug tests than commercial fishing vessel crewmembers.

Table 10

Yearly percentage differences between CFV and SPV drug test positivity rates

Year	CFV positivity rates in %	SPV positivity rates in %	+ or – diff in %
2003	32.35	4.69	-86
2004	23.17	4.26	-82
2005	12.74	2.80	-78
2006	17.50	7.32	-58
2007	16.91	2.46	-86
2008	12.00	8.18	-32
2009	26.80	1.19	-96
2010	19.18	1.55	-92
2011	21.59	2.63	-88

The tables and the histogram show large differences in Post-Accident drug test positivity rates between CFV crewmembers and SPV crewmembers. To determine if these differences are statistically significant at the 0.05 level and therefore not due to chance, the study used the two proportion *z*-test.

Applying the two proportion *z*-test formula discussed in Chapter IV, Table 11 shows the *z*-test scores and corresponding statistical values for yearly and total, overall Post-Accident positivity rates between CFV and SPV crewmembers. In seven out of nine years, the differences in positivity rates are statistically significant at the 0.01 level; that is, the probability that the differences in positivity rates are due to chance is less than one percent. In 2005, $p = 0.012$, thus statistically significant at the 0.05 level. In 2008, the differences are not statistically significant at $p = 0.19$. When comparing the total, overall results, the *z*-test shows the differences in Post-Accident positivity rates between CFV crewmembers and SPV crewmembers is still less than 0.01 and thus statistically significant.

Table 11

CFV and SPV Post-Accident drug test *z* scores with *p* values

	Commercial Fishing Vessels (CFV)			Small Passenger Vessels (SPV)				
Year	Drug Tests	Positives	Rate	Drug Tests	Positives	Rate	*z* score	*p* value
2003	68	22	0.3235	64	3	0.0469	4.054	*p = 0.01
2004	82	19	0.2317	142	6	0.0426	4.338	*p = 0.01
2005	100	14	0.1274	107	3	0.0280	2.270	*p = .012
2006	160	28	0.1750	123	9	0.0732	2.519	*p = 0.01
2007	136	23	0.1691	122	3	0.0246	3.850	*p = 0.01
2008	100	12	0.1200	98	8	0.0818	0.896	p = 0.19
2009	97	26	0.2680	84	1	0.0119	4.824	*p = 0.01
2010	73	14	0.1918	129	2	0.0155	4.457	*p = 0.01
2011	88	19	0.2159	152	4	0.0263	4.808	*p = 0.01
Total	917	177	0.1937	1021	39	0.0382	10.841	*p = 0.01

*Indicates statistically significant.

Given the results of the other eight years, the 2008 Post-Accident *z*-score might be considered an "outlier" or anomaly. There are some known "special causes" that may explain it. The CFV vessel drug test positivity rate was the lowest for the nine year period. It is possible that some commercial fishing vessel crewmember tests were not conducted due to the following: 1) serious marine incidents in remote locations, 2) the severity of the accidents and injuries, 3) the inability to rescue in a timely manner, or 4) the crewmembers and their vessels were lost at sea. Conversely, the 2008 SPV crewmember Post-Accident drug test positivity rate is the highest of the nine-year period. This result may be due to a drop in the number of tests performed in 2008. Also, the number of positive tests in any year is small enough that one casualty with multiple vessels or multiple involved crewmembers can skew the results. These data for this hypothesis are person-specific, not incident-specific. To determine if a special cause contributed to this statistical anomaly it would be necessary to examine the Coast Guard casualty data in more detail. Such a review is possible, but beyond the scope of this study.

The two proportion *z*-test showed the total, overall differences in Post-Accident positivity rates between SPV crewmembers and CFV crewmembers to be statistically significant.

VI. HYPOTHESIS 1B

Also in response to the first research question "[t]o what extent, if any, has chemical testing discouraged drug and alcohol use by commercial vessel personnel" Hypothesis 1B states yearly 2003-2011 Post-Accident alcohol test positivity rates from small passenger vessel crewmembers subject to chemical testing are significantly lower than yearly 2003-2011 Post-Accident alcohol test positivity rates from commercial fishing vessel crewmembers not otherwise subject to chemical testing. The Null Hypothesis is there is no difference in Post-Accident alcohol test positivity rates between the two groups.

The yearly 2003-2011 Post-Accident alcohol (ETOH) tests, positives, and resulting positivity rates for CFVs and SPVs are displayed in Table 12. "ETOH" is the chemical abbreviation of ethyl alcohol and is used in the tables and figures to refer to chemical tests specifically for alcohol. As with drug test positivity rates in Hypothesis 1A, ETOH positivity rates for both CFV crewmembers and SPV crewmembers gradually decrease year after year, with occasional upward spikes.

There is a gradual decrease with occasional upward positivity spikes in both categories. There may be many reasons for the differences in alcohol positivity rates within each separate category, including the availability of crewmembers to test for drugs and alcohol and the requirement that the alcohol test be administered within two hours of the serious marine incident. As is often the case with CFVs, crewmembers may not be available to test because they and their vessels may be lost at sea.

Table 12

CFV and SPV Post-Accident alcohol tests and results

	Commercial Fishing Vessels (CFV)			Small Passenger Vessels (SPV)		
Year	ETOH Tests a	Positives b	Rate c	ETOH Tests d	Positives e	Rate f
2003	16	3	0.1875	16	1	0.0626
2004	26	5	0.1923	88	3	0.0341
2005	29	2	0.0689	69	1	0.0145
2006	67	5	0.0746	83	0	0
2007	61	3	0.0492	118	5	0.0424
2008	51	3	0.0588	76	0	0
2009	45	3	0.0666	72	1	0.0139
2010	43	2	0.0465	123	0	0
2011	91	1	0.0110	136	1	0.0074
Mean			0.0839			0.0194
STDEV			0.0629			0.0222

Another contributing factor is the number of positives in any year is quite small so one serious marine incident can markedly affect the positivity rate for that year. Despite spikes in positivity, Post-Accident alcohol test positivity rates of SPVs with crewmembers subject to chemical testing are much lower than CFVs with crewmembers not otherwise subject to chemical as shown in the Figure 2 histogram below.

Figure 2

Differences between CFV and SPV alcohol test positivity rates

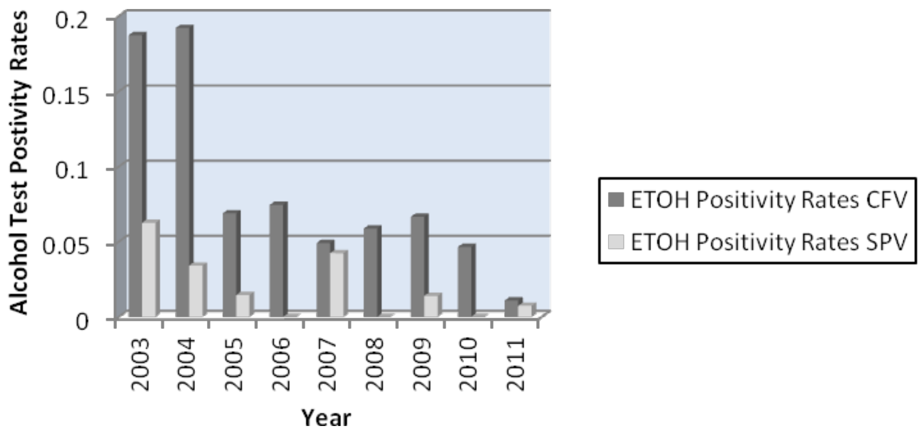


Table 13 shows the year after year Post-Accident alcohol test positivity rates of SPV crewmembers to be at least 14% lower (2007), and as much as 100% lower (2006, 2008, and 2010) than Post-Accident alcohol positivity rates of CFV crewmembers. SPV crewmembers averaged 73% fewer Post-Accident positive alcohol tests than CFV crewmembers.

Table 13

Alcohol positivity rates of CFV crewmembers versus SPV crewmembers

Year	CFV Crewmember ETOH positivity rates in percentages	SPV Crewmember ETOH positivity rates in percentages	% differences of SPV vs. CFV Crewmembers
2003	0.1875	0.0626	-67%
2004	0.1923	0.0341	-82%
2005	0.0689	0.0145	-79%
2006	0.0746	0	-100%
2007	0.0492	0.0424	-14%
2008	0.0588	0	-100%
2009	0.0666	0.0139	-79%
2010	0.0465	0	-100%

2011	0.0110	0.0074	-33%

The tables and histogram show large differences in Post-Accident alcohol test positivity rates between commercial fishing vessel crewmembers and small passenger vessel crewmembers. To determine if these differences are statistically significant at the 0.05 level and therefore not due to chance, this study uses the two proportion *z*-test as discussed in Chapter IV.

Table 14 shows the *z*-test scores and corresponding statistical values for yearly and total, overall Post-Accident alcohol test positivity rates between CFV and SPV crewmembers. In four out of nine years, the differences in positivity rates are statistically significant. In 2003, 2005, 2007, 2009, and 2011 the probabilities were greater than 0.05 and thus not statistically significant. When comparing the total, overall Post-Accident alcohol positivity rates, the *z*-test shows the differences are statistically significant.

Table 14

CFV and SPV Post-Accident alcohol tests, *z* scores with *p* values

	Commercial Fishing Vessels (CFV)			Small Passenger Vessels (SPV)				
Year	ETOH Tests	Positives	Rate	ETOH Tests	Positives	Rate	*z* score	*p* value
2003	16	3	0.1875	16	1	0.0626	1.069	0.1446
2004	26	5	0.1875	88	3	0.0341	2.774	*0.0028
2005	29	5	0.0689	69	1	0.0145	1.428	0.4129
2006	67	5	0.0746	83	0	0	2.531	*0.0057
2007	61	3	0.0492	118	5	0.0424	0.2089	0.4207
2008	51	3	0.0588	76	0	0	2.139	*0.0069
2009	45	3	0.0666	72	1	0.0139	1.528	0.0643
2010	43	2	0.0465	123	0	0	2.406	*0.0082
2011	91	1	0.0110	136	1	0.0074	0.287	0.3897
Total	429	27	0.0629	781	12	0.0154	4.482	*< 0.01

*Indicates statistically significant.

There is a gradual decrease with occasional upward positivity spikes in both categories which may be attributed to the availability of crewmembers to test for drugs and alcohol as noted in the discussion under Hypothesis 1A. The SMI's remoteness is more acute in alcohol testing because the test must be given within two hours of the accident.

VII. HYPOTHESIS 1C

In final response to the first research question “[t]o what extent, if any, has chemical testing discouraged drug and alcohol use by commercial vessel personnel” Hypothesis 1C states yearly 2003-2011 Post-Accident drug test positivity rates from all crewmembers subject to chemical testing from all vessels are significantly lower than yearly 2003-2011 Post-Accident drug test positivity rates from commercial fishing vessel crewmembers not otherwise subject to chemical testing. The Null Hypothesis is there is no difference in drug test positivity rates between the two groups.

The yearly 2003-2011 numbers of Post-Accident drug tests, verified positives, and resulting positivity rates for CFV crewmembers and Post-Accident drug tests, verified positives, and positivity rates for ALL vessels with crewmembers subject to chemical testing are displayed in Table 15. As with Hypotheses 1A and 1B, the Post-Accident drug test positivity rates of all crewmembers subject to chemical testing are much lower than the drug test positivity rates of CFV crewmembers not otherwise subject to chemical testing. As expected, the Post-Accident drug test positivity rates of all crewmembers from all vessels gradually decrease year after year at about the same rate as commercial fishing vessel Post-Accident drug test rates.

Table 15

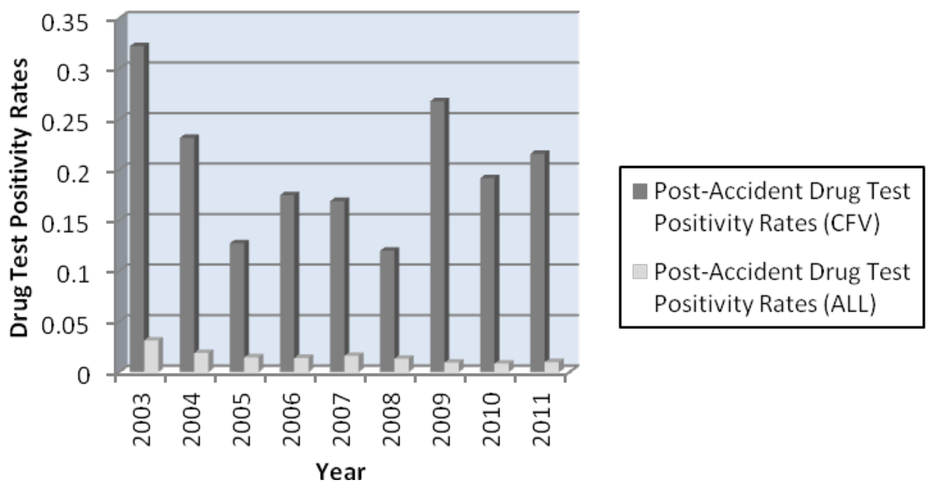
Post-Accident drug test positivity rates, commercial fishing vessels versus all vessels

	Commercial Fishing Vessels (CFV)			ALL Vessels (ALL)		
Year	Drug Tests	Positives	Rate	Drug Tests	Positives	Rate
2003	68	22	0.3225	5,295	165	0.0312
2004	82	19	0.2317	4,579	86	0.0188
2005	110	14	0.1274	6,263	90	0.0144
2006	160	28	0.1750	6,300	87	0.0138
2007	136	23	0.1691	7,211	115	0.0159
2008	100	12	0.1200	7,259	95	0.0131
2009	97	26	0.2680	6,497	60	0.0092
2010	73	14	0.1918	6,857	57	0.0083
2011	88	19	0.2159	6,941	67	0.0097
Mean			0.2024			0.0149
STDEV			0.0616			0.0065

As with Hypotheses 1A and 1B, there are gradual decreases with occasional spikes in positivity from 2003-2011. The reasons for the spikes were discussed in those hypotheses. Despite spikes in positivity, Post-Accident drug test positivity rates of all vessels with crewmembers subject to comprehensive chemical testing are always lower than CFVs with crewmembers not subject to comprehensive chemical drug testing except for Post-Accident drugs and alcohol as shown in the Figure 3 histogram below.

Figure 3

Differences between CFV and ALL drug test positivity rates



The tables and the histogram for Hypothesis 1C show that the differences in Post-Accident drug test positivity rates between CFV crewmembers and all crewmembers subject to comprehensive chemical testing are much greater than the differences between CFV crewmembers and SPV crewmembers.

As shown in Table 16, Post-Accident positivity rates of crewmembers subject to chemical testing from ALL vessels are at least 89% lower (2008) and as much as 97% lower (2009) than Post-Accident positivity rates of commercial fishing vessel crewmembers. Crewmembers subject to comprehensive chemical testing from ALL vessels averaged 92% fewer Post-Accident positive drug tests than crewmembers of commercial fishing vessels not subject to comprehensive chemical testing except for Post-Accident drug and alcohol tests.

Table 16

Percentage differences in CFV drug test positivity rates compared to all vessels

Year	CFV positivity rates in percentages	ALL positivity rates in percentages	+ or – diff in %
2003	0.3225	0.0312	-90%
2004	0.2317	0.0188	-92%
2005	0.1274	0.0144	-89%
2006	0.1750	0.0138	-92%
2007	0.1691	0.0159	-90%
2008	0.1200	0.0131	-89%
2009	0.2680	0.0092	-97%
2010	0.1918	0.0083	-96%
2011	0.2159	0.0097	-96%

Applying the two proportion *z*-test formula discussed in Chapter IV, Table 17 shows the *z*-test scores and corresponding statistical values for yearly and overall Post-Accident positivity rates between commercial fishing vessel and small passenger vessel crewmembers. In all years, the differences in positivity rates are statistically significant at the 0.01 level; that is, the probability that the differences are due to chance is less than 1%.

Here, the *z* scores are so high they are "off the chart," meaning the *p* value is significantly below 0.01; therefore, < 0.01 is placed in the box. While the positivity rates in both categories gradually decrease year after year, perhaps due to the general decline in drug use as reflected in the Quest Diagnostics statistics and the DOD studies, the differences are still statistically significant. We know that crewmembers of all vessels, except commercial fishing vessels less than 200 tons without a licensed master, are subject to chemical testing. Given that the primary difference between the two groups is that one group is subject to comprehensive chemical testing and the other is not, the differences in positivity rates is startling.

Table 17

CFV Post-Accident positive drug test rates compared to ALL vessels with *z* scores and *p* values

	Commercial Fishing Vessels (CFV)			ALL Vessels (ALL)				
	Drug Tests	Positives	Rate	Drug Tests	Positives	Rate	*z* score	*p* value
2003	68	22	0.3225	5,295	165	0.0312	13.0587	*<0.01
2004	82	19	0.2317	4,579	86	0.0188	12.8598	*<0.01
2005	110	14	0.1274	6,263	90	0.0144	09.2650	*<0.01
2006	160	28	0.1750	6,300	87	0.0138	15.2272	*<0.01
2007	136	23	0.1691	7,211	115	0.0159	13.0352	*<0.01
2008	100	12	0.1200	7,259	95	0.0131	08.8706	*<0.01
2009	97	26	0.2680	6,497	60	0.0092	22.3006	*<0.01
2010	73	14	0.1918	6,857	57	0.0083	15.4844	*<0.01
2011	88	19	0.2159	6,941	67	0.0097	17.4897	*<0.01
Total	914	177	0.1936	57,202	822	0.0144	41.3716	*<0.01

*Indicates statistically significant.

VIII. HYPOTHESIS 2A

In response to the second research question "[t]o what extent, if any, does chemical testing reduce the potential for marine casualties related to drug and alcohol use" Hypothesis 2A states yearly 2003-2011 ratios of Post-Accident positive drug tests per serious marine incident from small passenger vessel crewmembers subject to chemical testing are significantly lower than corresponding Post-Accident positive drug tests per serious marine incident from commercial fishing vessel crewmembers not otherwise subject to chemical testing. The Null Hypothesis is there is no difference in Post-Accident positive drug tests per serious marine incident between the two groups.

The yearly 2003 through 2011 Post-Accident positive drug tests and the yearly 2003-2011 serious marine incidents in which drug tests are reported are shown for commercial fishing vessels and small passenger vessels in Table 19. Counting only serious marine incidents in which drug tests are reported eliminates possible variations due to differing crew sizes or the number of directly involved crewmembers. In short, it is more accurate. CFV positive drug tests per SMI in which Post-Accident drug tests are reported are much higher than SPV positive drug tests per SMI in which drug tests are reported.

Table 18

Ratios of CFV and SPV Post-Accident positive drug tests per SMI

	Commercial Fishing Vessels (CFV)			Small Passenger Vessels (SPV)		
Year	SMIs	Positive Drug Tests	Ratio	SMIs	Positive Drug Tests	Ratio
2003	27	12	0.4444	26	2	0.0769
2004	38	13	0.3421	63	6	0.0952
2005	62	9	0.1451	45	3	0.0666
2006	106	18	0.1698	58	8	0.1379
2007	69	13	0.1884	50	3	0.0600
2008	53	8	0.1509	40	5	0.1250
2009	44	15	0.3409	44	1	0.0227
2010	45	11	0.2444	51	1	0.0196
2011	40	13	0.3250	58	4	0.0689
Mean			0.2612			0.0748
STDEV			0.1061			0.0403

As with Hypotheses 1A and 1B, there are gradual decreases with occasional spikes in positivity from 2003-2011. The reasons for the spikes were discussed in those hypotheses. Despite spikes in positivity, Post-Accident positive drug tests per serious marine incident of all vessels with crewmembers subject to comprehensive chemical testing are always lower than positive drug tests per SMI of CFVs with crewmembers not subject to comprehensive chemical testing except for Post-Accident drugs and alcohol as shown in the Figure 4 histogram below. Because of the relatively small numbers, a few more or less positive tests can affect large changes in the ratios.

Figure 4

Differences between CFV and SPV positive drug tests per SMI

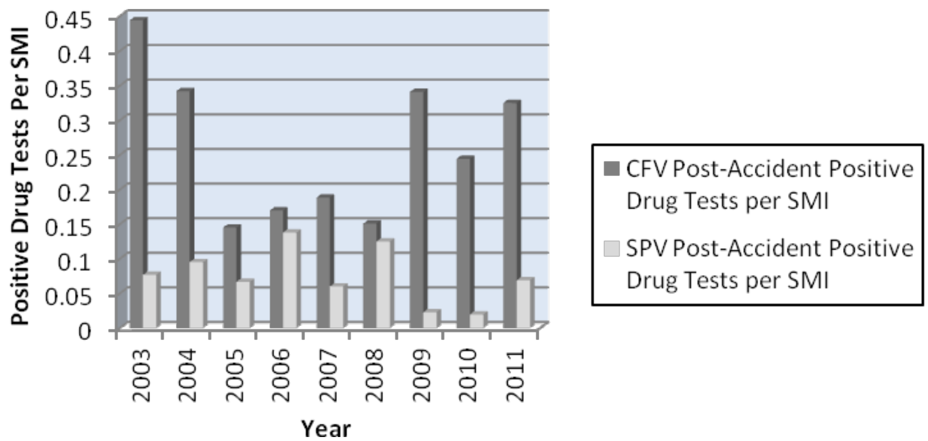


Table 19

Percentage differences between CFV and SPV positive drug tests per SMI

Year	CFV positive drug tests per SMI (column “c” from Table 13)	SPV positive drug tests per SMI (column “f” from Figure 13)	% difference that SPV ratios are less than CFV ratios.
2003	0.4444	0.0769	-83%
2004	0.3421	0.0952	-72%
2005	0.1451	0.0666	-54%
2006	0.1698	0.1379	-19%
2007	0.1884	0.0600	-68%
2008	0.1509	0.1250	-17%
2009	0.3409	0.0227	-93%
2010	0.2444	0.0196	-93%
2011	0.3250	0.0689	-79%

Table 19 shows the SPV crewmember percentage of Post-Accident positive drug tests per serious marine incident in which a drug test is reported to be at least 17% lower (2008) and as much as 93% lower (2010) than the CFV Post-Accident positive drug tests per SMI for any year, 2003-2011. During that time period, the SPV ratios of Post-Accident positive drug tests per SMI averaged 64% lower than the CFV Post-Accident positive drug test per SMI.

The tables and the histogram for Hypothesis 2A show the differences in Post-Accident positive drug tests per SMI between CFV crewmembers subject to comprehensive chemical testing and crewmembers of SPVs not subject to comprehensive chemical testing. To determine if these differences are statistically significant at the 0.05 level and therefore not due to chance, I used the two proportion *z*-test as described in Chapter IV.

Table 20 shows *z*-test scores and corresponding *p* values for yearly and overall Post-Accident positive drug tests per serious marine incident between CFV and SPV crewmembers. In five out of nine years (2003, 2004, 2009, 2010, and 2011), the differences in positivity rates are statistically significant at the 0.05 level. In this case, the *p* values are less than 0.01; that is, the probability that the differences in positivity rates are due to chance is less than one percent. In 2007, the differences are statistically significant at the 0.05 level with a *p* value of 0.02. In 2005, 2006, and 2008 the differences are not statistically significant but the total, overall results are statistically significant.

Table 20

Ratios of CFV and SPV Post-Accident positive drug tests per SMI with *z* scores and *p* values

	Commercial Fishing Vessels (CFV)			Small Passenger Vessels (SPV)				
	SMIs	Positive Drug Tests	Ratio	SMIs	Positive Drug Tests	Ratio	*z* score	*p* value
2003	27	12	0.4444	26	2	0.0769	3.034	*< 0.01
2004	38	13	0.3421	63	6	0.0952	3.075	*< 0.01
2005	62	9	0.1451	45	3	0.0666	1.270	0.102
2006	106	18	0.1698	58	8	0.1379	0.534	0.2955
2007	69	13	0.1884	50	3	0.0600	2.027	*0.0212
2008	53	8	0.1509	40	5	0.1250	0.357	0.3615
2009	44	15	0.3409	44	1	0.0227	3.869	*< 0.01
2010	45	11	0.2444	51	1	0.0196	3.324	*< 0.01
2011	40	13	0.3250	58	4	0.0689	3.290	*< 0.01
Total	484	112	0.2314	435	33	0.0758	6.458	*< 0.01

*Indicates statistically significant.

IX. HYPOTHESIS 2B

In further response to research question number two "[t]o what extent, if any, does chemical testing reduce the potential for marine casualties related to drug and alcohol use" Hypothesis 2B states the yearly 2003-2011 ratios of Post-Accident positive alcohol tests per serious marine incident from small passenger vessel crewmembers subject to chemical testing are significantly lower than corresponding Post-Accident positive alcohol tests per serious marine incident from commercial fishing vessel crewmembers not otherwise subject to chemical testing. The Null Hypothesis is there is no difference in positive alcohol tests per serious marine incident between the two groups.

The yearly 2003 through 2011 Post-Accident positive alcohol tests and the yearly 2003-2011 SMIs in which alcohol tests are reported are shown for CFVs and SPVs in Table 21. Counting only serious marine incidents in which alcohol tests are reported eliminates possible variations due to differing crew sizes or the number of directly involved crewmembers. In short, it is more accurate. As the table shows, the ratio of CFV positive alcohol tests per SMI is much higher than the ratio of SPV positive alcohol tests per SMI. The CFV ratio of positive alcohol tests per SMI gradually decreases as does the SPV ratio of positive alcohol tests per SMI but not as dramatically.

Table 21

Ratios of CFV and SPV Post-Accident positive alcohol tests to SMIs

	Commercial Fishing Vessels (CFV)			Small Passenger Vessel (SPV)		
Year	SMIs	Positive ETOH Tests	Ratio	SMIs	Positive ETOH Tests	Ratio
2003	8	2	0.2500	7	1	0.0143
2004	15	5	0.3333	33	3	0.0909
2005	21	2	0.0952	30	1	0.0333
2006	32	3	0.0937	30	0	0.0000
2007	33	3	0.0909	48	4	0.0833
2008	30	2	0.0625	35	0	0.0000
2009	25	3	0.12	39	1	0.0256
2010	23	1	0.0434	46	0	0.0000
2011	35	1	0.0285	53	1	0.0188
Mean			0.12417			0.0296
STDEV			0.10120			0.0347

Table 21 shows positive alcohol tests per SMI in both categories. There are spikes in positivity but the number of tests and results are very small which may account for such spikes. In all years, the SPV positive alcohol tests per SMI in which alcohol tests were reported were consistently less than CFV positive alcohol tests per SMI in which alcohol tests were reported as shown in the Figure 5 histogram.

Figure 5

Differences between CFV and SPV positive alcohol (ETOH) tests per SMI

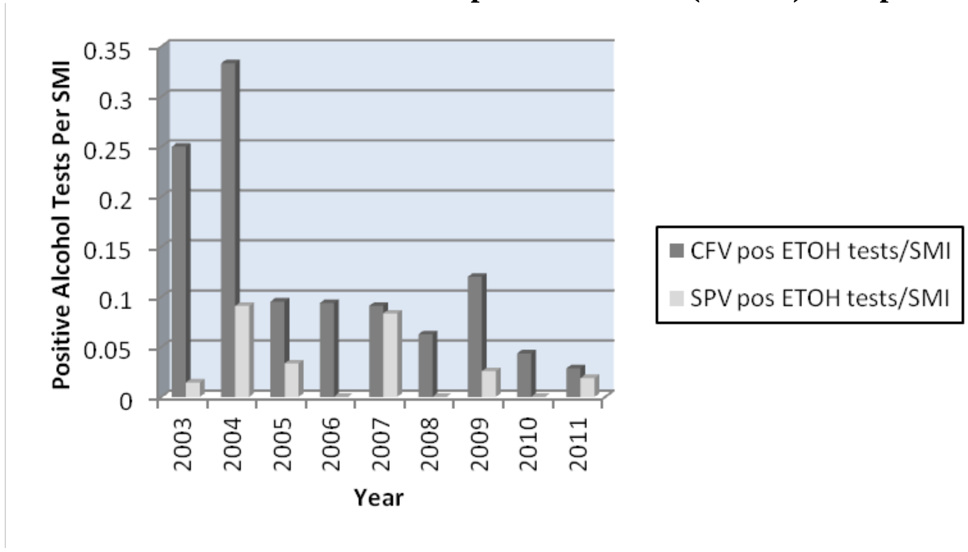


Table 22 below compares ratios of positive alcohol tests per SMI and the percentage differences for each year, 2003-2011. It shows the SPV crewmember percentage of Post-Accident positive alcohol tests per SMI in which a Post-Accident test is reported to be at least 8% lower (2007) and as much as 100% lower (2006, 2008, and 2010) than CFV crewmember Post-Accident positive alcohol tests per SMI for any year. During that time period, the SPV ratios of Post-Accident positive alcohol tests per SMI averaged 73% lower than the CFV Post-Accident positive alcohol tests per SMI.

Table 22

Percentage differences between CFV and SPV positive alcohol tests per SMI

Year	CFV positive ETOH tests per SMI (column "c" from Figure 16)	SPV positive ETOH tests per SMI (column "f" from Figure 16)	% difference that SPV ratios are less than CFV ratios.
2003	0.2500	0.0143	-94%
2004	0.3333	0.0909	-73%
2005	0.0952	0.0333	-65%
2006	0.0937	0.0000	-100%
2007	0.0909	0.0833	-8%
2008	0.0625	0.0000	-100%
2009	0.1200	0.0256	-79%
2010	0.0434	0.0000	-100%
2011	0.0285	0.0188	-34%

The tables and the histogram for Hypothesis 2B show the differences in Post-Accident alcohol positive tests per SMI between CFV crewmembers subject to comprehensive chemical testing and SPV crewmembers not subject to comprehensive chemical testing. To determine if these differences are statistically significant at the $p = 0.05$ level and therefore not due to chance, I used the two proportion *z*-test. Table 23 shows the *z*-test scores and corresponding statistical values for yearly and overall Post-Accident positive alcohol tests per SMI between CFV crewmembers and SPV crewmembers. Although the differences are not statistically significant in seven out of nine years with *p* values ranging from 0.06 to 0.38, the *p* value for the 2003-2011 total, overall results is 0.0007, and thus statistically significant.

Table 23

Ratios of CFV and SPV Post-Accident positive alcohol tests per SMI with *z* scores and *p* values

	Commercial Fishing Vessels (CFV)			Small Passenger Vessel (SPV)				
Year	SMIs	positives	ratio	SMIs	positives	ratio	*z* scores	*p* values
2003	8	2	0.2500	7	1	0.0143	0.518	0.305
2004	15	5	0.3333	33	3	0.0909	2.089	*0.023
2005	21	2	0.0952	30	1	0.0333	0.925	0.179
2006	32	3	0.0937	30	0	0.0000	1.719	*0.044
2007	33	3	0.0909	48	4	0.0833	0.119	0.117
2008	30	2	0.0625	35	0	0.0000	1.552	0.061
2009	25	3	0.12	39	1	0.0256	1.521	0.066
2010	23	1	0.0434	46	0	0.0000	1.425	0.078
2011	35	1	0.0285	53	1	0.0188	0.299	0.386
Total	222	22	0.0991	321	11	0.0342	3.109	*0.0007

*Indicates statistically significant.

As with large variations in alcohol test results in Hypothesis 1B, similar variations exist in Hypothesis 2B. Two factors are known to contribute to these variations. The first factor is the two hour time period in which alcohol tests must be ordered. This time limitation on alcohol testing will leave out many instances in which tests could be ordered but for the remoteness of the vessel's location, especially CFVs that ordinarily operate farther offshore than SPVs. The second factor is the relatively small number of tests that could cause wide swings in percentages of positive tests per SMI. Even with these factors, the ratio of positive alcohol tests per SMI consistently shows crewmembers of SPVs test positive for alcohol less than CFV crewmembers and the results are statistically significant overall.

X. HYPOTHESIS 3

In response to the third research question "[t]o what extent, if any, does chemical testing enhance the safety of the maritime transportation industry" Hypothesis 3 states the yearly 2003-2011 Post-Accident drug test positivity rates from all vessels with crewmembers subject to chemical testing will correlate positively and strongly with decreasingly lower Random drug test positivity rates from 2003-2011 for all vessels with crewmembers subject to chemical testing. The Null Hypothesis is that there is no correlation of Post-Accident positivity with downward Random positivity rates.

Table 24 shows yearly 2003 through 2011 Pre-Employment, Random, and Post-Accident Random drug test positivity rates from ALL vessels with crewmembers subject to chemical testing. The Pre-Employment positivity rate is obtained by dividing the total number of Verified Positive Test Results by the total number of Pre-Employment drug tests. For 2011, the total number of Pre-Employment, Verified Positive Test Results is 1,723 and the total number of Pre-Employment drug tests is 46,746. Dividing the total number of Pre-Employment positive drug tests by the total number of tests yields a Pre-Employment positivity rate of .03685. The positivity rates for Post-Accident are obtained in the same manner; however, the Coast Guard calculates the Random positivity rate differently.

Table 24

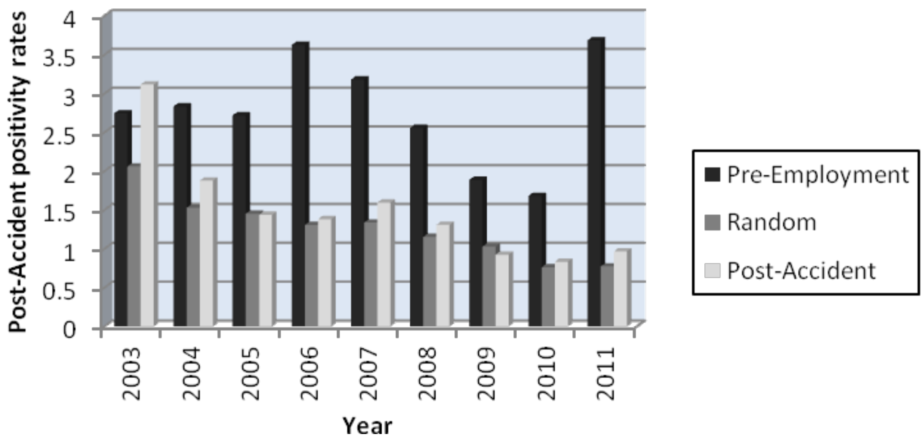
MIS Pre-Employment, Random, and Post-Accident positivity rates

	Pre-Employment ALL			Random ALL			Post-Accident ALL		
Year	Tests	Positives	Rate	Tests	Positives	Rate	Tests	Positives	Rate
2003	37,984	1,043	0.02745	45,845	944	0.02059	5,295	165	0.03116
2004	36,737	1,041	0.02833	43,004	657	0.01527	4,579	86	0.01878
2005	51,177	1,391	0.02718	53,661	779	0.01451	6,263	90	0.01437
2006	56,612	2,053	0.03626	54,701	714	0.01305	6,300	87	0.01381
2007	41,883	1,332	0.03180	56,886	761	0.01337	7,211	115	0.01594
2008	36,567	935	0.02556	57,480	663	0.01153	7,259	95	0.01308
2009	29,729	561	0.01887	60,630	623	0.01027	6,497	60	0.00923
2010	45,476	764	0.01680	66,847	509	0.00761	6,857	57	0.00831
2011	46,746	1,723	0.03685	62,908	486	0.00772	6,941	67	0.00965
Mean			0.02767			0.01266			0.01493
STDEV			0.00686			0.00404			0.00697

As previously explained in “Operational Definitions of Variables,” Random “positives” consist of the total number of Random Verified Positive Test Results plus the total number of Adulterated, Substituted, “Shy Bladder” with No Medical Explanation, and other refusals to submit to testing. The Random positivity rates are obtained by dividing those “positives” by the total number of Random tests. The 2003-2011 Pre-Employment, Random, and Post-Accident positivity rates from Table 24 are displayed graphically in Figure 6.

Figure 6

MIS Pre-Employment, Random, and Post-Accident drug test positivity rates

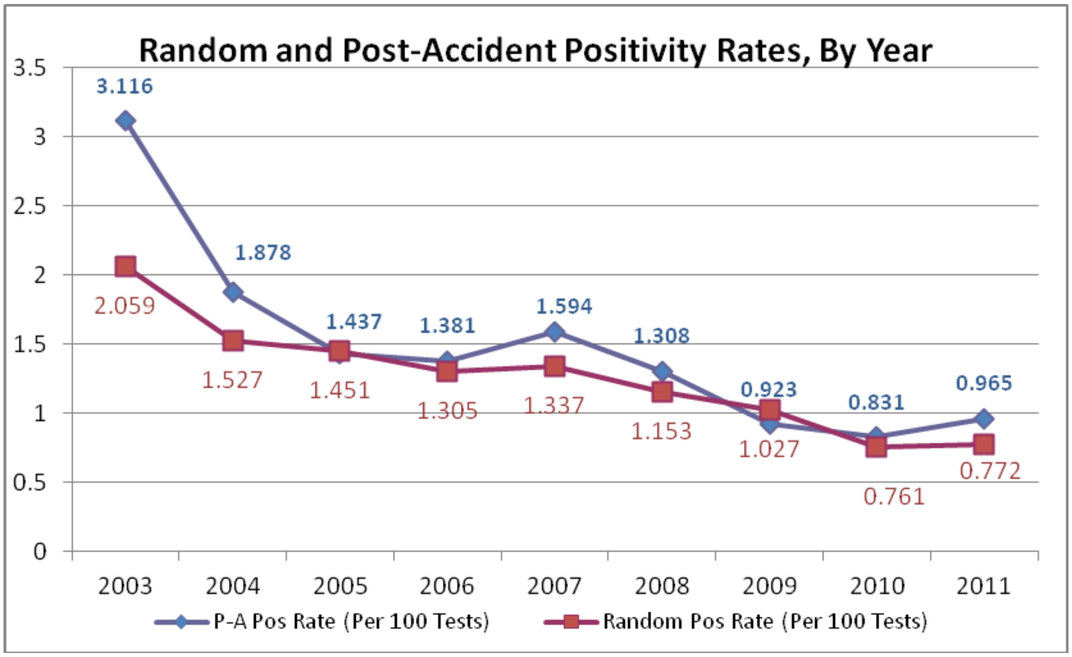


Crewmembers not passing a Pre-Employment chemical test for dangerous drugs are not subject to further testing because they are not hired. Pre-Employment positivity rates therefore do not directly affect Random or Post-Accident positivity rates; however, the differences in positivity rates between Pre-Employment and Random as well as between Pre-Employment and Post-Accident are startling and are unlikely to be attributed to chance. The data appear to show that the Pre-Employment drug test eliminates those persons whose drug use would appear to be so much a part of their lives that they are unable to suspend it sufficiently long enough to pass a drug test even with advance notice.

From the tables and histogram, the Random and Post-Accident positivity rates appear to have a gradually decreasing trend. That trend is shown graphically in Figure 7 below.

Figure 7

Trend Line of Random and Post-Accident positivity rates



The trend in Figure 7 is significant because Random positivity rates are derived from a very large sample size of crewmembers eligible for chemical testing as shown in Table 24. As shown in Table 25, the yearly sample sizes of Random test results represent at least 53% and as much as 63.6% of crewmembers eligible for testing, more than a mere sampling of crewmembers subject to Random drug tests. These high sampling percentages provide confidence that the Random drug test positivity rates fairly represent the level and trend of drug use among commercial vessel personnel subject to chemical testing.

Table 25

Percentages of Crewmembers Randomly Tested

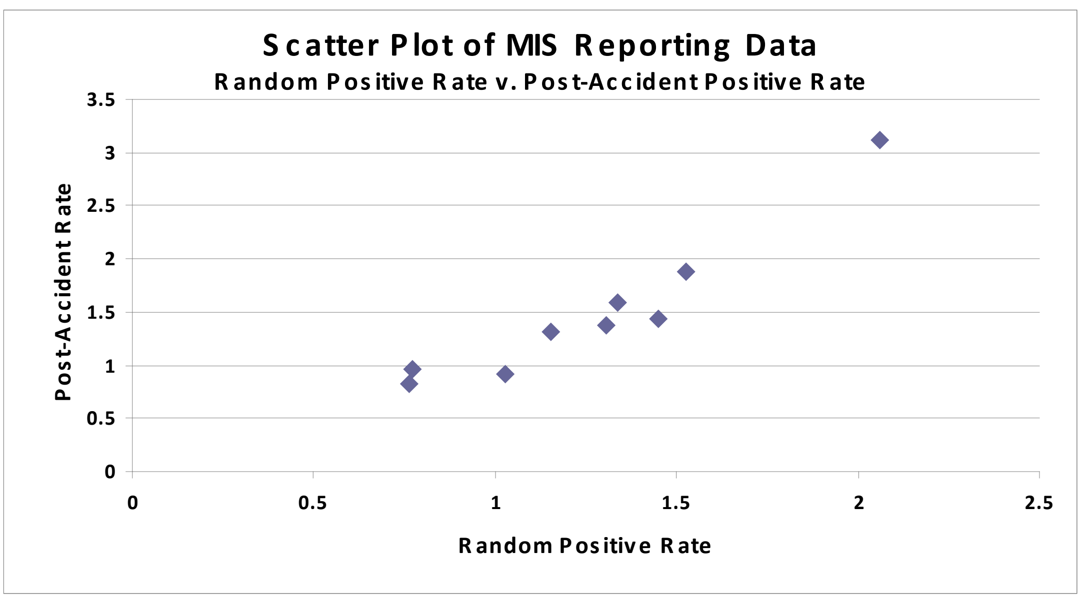
ALL VESSELS

Year	Percentage of Crewmembers Randomly Tested
2003	56.2
2004	55.7
2005	57.1
2006	61.5
2007	63.6
2008	57.0
2009	53.2
2010	59.7
2011	57.3

Figure 8 shows the Random and Post-Accident positivity rates in a scatter plot.

Figure 8

Scatter Plot of Random and Post-Accident Positivity Rates

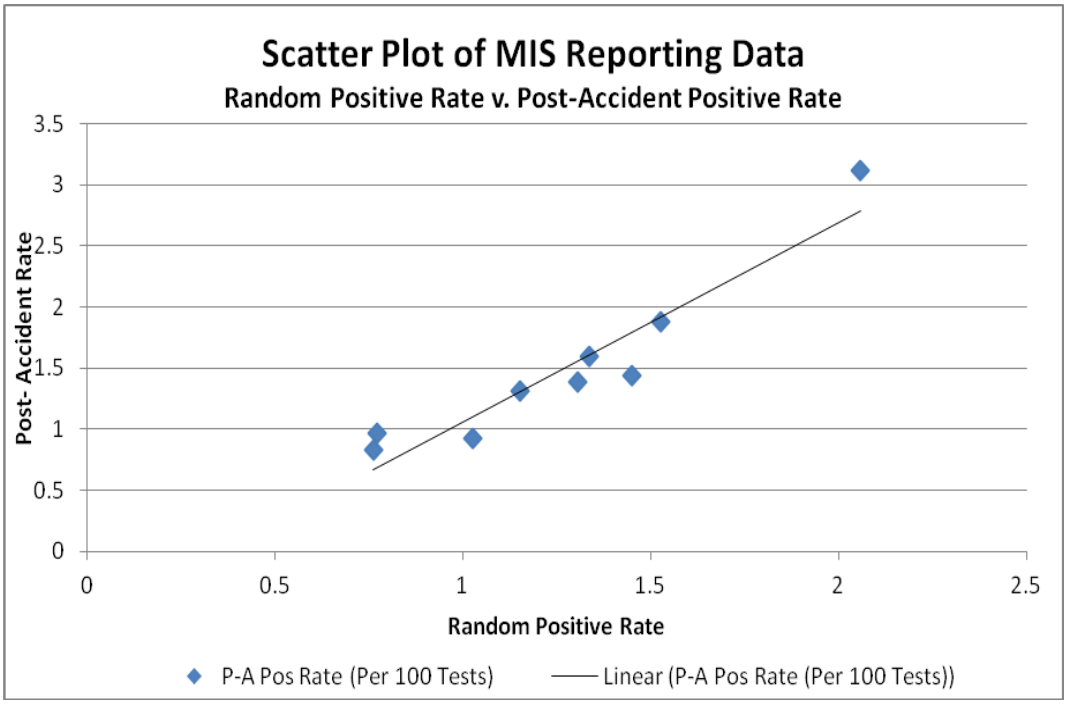


The Figure 8 scatter plot shows a strong linear relationship between Random positivity rates represented by the horizontal or *x* axis and the Post-Accident positivity rates represented by the vertical or *y* axis. That relationship suggests a regression line as shown in the Figure 9 scatter plot.

The formula for the best-fitting regression line is $y = mx + b$ where *m* is the slope of the line and *b* is the *y*-intercept. The *x* values are the Random positivity rates and the *y* values are the Post-Accident positivity rates. The slope of a line is the change in *y* values over the change in *x* values. The y intercept is the point on the *y* axis where the *x* value is zero. Applying the LINEST formula in EXCEL® yields a slope of 1.632. Applying the INTERCEPT formula in EXCEL® yields -0.572 as the *y* intercept. The best fitting regression line ($y = mx + b$) for the Random and Post-Accident positivity rates from Table 17 is depicted in Figure 9 on the next page.

Figure 9

Scatter Plot and Regression line for Random versus Post-Accident positivity rates



The regression line shows that within the range of values for which there is data (2003-2011) there is a very straight linear relationship between Random and Post-Accident positivity rates. The regression line also shows Random drug test positivity is a fairly accurate predictor of Post-Accident drug test positivity. Once the Random rate approaches zero, the line may no longer be linear; therefore, this study does not make any predictions of Post-Accident positivity rates based on Random positivity rates that are not part of the data. Further, there appears to be a strong correlation between Random and Post-Accident drug test positivity rates. Applying the CORREL formula in EXEL® to the 2003-2011 Arrays of Random and Post-Accident drug test positivity rates from Table

24, the *correlation coefficient* is 0.94642525, showing a strong, linear relationship. It is sufficient to conclude that decreasing Random positivity rates have, on the average, predicted decreasing Post-Accident positivity rates at least from 2003-2011. Lower Post-Accident positivity rates results in fewer serious marine incidents with drug involvement, thereby enhancing the safety of the maritime transportation industry at least to the extent of fewer positive drug tests per serious marine incident.

XI. DISCUSSION

A. SUMMARY

Research question number one is "[t]o what extent, if any, has chemical testing discouraged drug and alcohol use by commercial vessel personnel." In response to that research question, this study showed yearly 2003-2011 Post-Accident drug test positivity rates from small passenger vessel crewmembers were significantly lower than corresponding Post-Accident drug test positivity rates from commercial fishing vessel crewmembers. The difference between the two categories is small passenger vessel crewmembers are subject to comprehensive chemical testing and commercial fishing vessel crewmembers are not subject to comprehensive chemical testing except for Post-Accident drugs and alcohol. Comprehensive chemical testing includes Pre-Employment, Random, Reasonable Cause, and Post-Accident. The positivity rate differences are statistically significant and not due to chance; therefore, I rejected the null hypothesis that there is no difference in Post-Accident drug test positivity rates between the two categories.

This author expected Post-Accident positivity rates for small passenger vessel crewmembers to be less than those of commercial fishing vessel crewmembers because experiences with the military's drug testing program showed random testing to be an effective deterrent. The Mehay and Pacula (1999) study corroborates this expectation. Using 1995 data from the National Household Survey of Drug Abuse (NHSDA) and the Department of Defense's Worldwide Survey of Drug Abuse (DODWWS), Mehay and Pacula (1999) examined the deterrence effect by comparing differences in illicit drug use between the military and the civilian populations. They found the military's strict anti-drug program to be highly effective in deterring illicit drug use to the extent drug participation in the military ranged between 4% and 16% lower than in the civilian sector, depending on the age group. It was reasonable to assume the commercial vessel personnel chemical drug and alcohol testing program would show crewmembers subject to chemical testing have a lower positivity rate than crewmembers not subject to chemical testing. I was surprised to see that the differences in Post-Accident positivity rates between small passenger vessel crewmembers were at least 32% (2008) and as much as 96% (2009) lower than Post-Accident drug test positivity rates of commercial fishing vessel crewmembers. Small passenger vessel crewmembers subject to comprehensive chemical testing had a 2003-2011 average of 77% fewer Post-Accident positive drug tests than commercial fishing vessel crewmembers not subject to comprehensive chemical testing. That is substantially more than a 4% to 16% difference between the military and civilian populations.

Also in response to research question number one, this study showed yearly 2003-2011 Post-Accident alcohol test positivity rates from SPV crewmembers subject to comprehensive chemical testing were significantly lower than yearly 2003-2011 Post-Accident alcohol test positivity rates from CFV crewmembers not otherwise subject to chemical testing except for Post-Accident drugs and alcohol. The overall differences in Post-Accident alcohol test positivity rates are statistically significant and not due to chance; therefore, I rejected the null hypothesis that there is no difference in Post-Accident alcohol test positivity rates between the two categories.

I did not expect to see the differences in Post-Accident alcohol test positivity rates of SPVs to be at least 14% (2007) and as much as 100% (2006, 2008, and 2010) lower than Post-Accident alcohol test positivity rates of CFV crewmembers. SPV crewmembers subject to comprehensive chemical testing had a 2003-2011 average of 72% fewer Post-Accident positive alcohol tests than CFV crewmembers not subject to comprehensive chemical testing. This author expected lower alcohol test positivity rates but did not expect that the differences would be this large and statistically significant. This is especially so because the Coast Guard does not mandate Pre-Employment, Periodic, or Random alcohol testing. However, crewmembers are subject to Reasonable Cause tests for alcohol as prescribed in 33 C.F.R. pt. 95. Credentialed crewmembers testing positive for alcohol use under that part also face suspension and revocation proceedings in addition to any personnel actions their employers impose.

Another reason for large differences in positivity rates may be due to credentialed crewmembers potentially facing suspension and revocation proceedings if they are convicted of operating a motor vehicle while under the influence of alcohol. Driving While Intoxicated or Driving Under the Influence are offences described in the National Driver Register Act, 49 U.S.C. 30304(a)(3)(A), and violations therefore would constitute a wrongful violation of 46 U.S.C. § 7703(3). These deterrents, plus being subject to comprehensive chemical testing for drugs, would appear to account for the large differences in alcohol positivity rates between commercial fishing vessel crewmembers and small passenger vessel crewmembers.

In final response to research question number one, this study showed yearly 2003-2011 Post-Accident drug test positivity rates of all crewmembers subject to comprehensive chemical testing from all vessels were substantially lower than positivity rates of CFV crewmembers not subject to comprehensive chemical testing except for Post-Accident drugs and alcohol. The differences in Post-Accident drug test positivity rates between the two categories are statistically significant and not due to chance; therefore, I rejected the null hypothesis that there is no difference in Post-Accident drug test positivity rates between the two categories.

This author was surprised to learn the differences in Post-Accident positivity rates between the two categories of crewmembers were at least 89% lower (2008) and as much as 97% lower (2009) than Post-Accident drug test positivity rates of commercial fishing vessel crewmembers not subject to comprehensive chemical testing. All vessels with crewmembers subject to comprehensive chemical testing had a 2003-2011 average of 92% fewer Post-Accident positive drug tests than commercial fishing vessel crewmembers not subject to comprehensive chemical testing. These results were also surprising because it appeared SPVs would be the safest of all vessels with crewmembers subject to chemical testing. Upon further consideration, small passenger vessels ordinarily would be underway more often than other vessels because they are carrying passengers on regular schedules exposing those vessels to the hazards of navigating in close quarters with frequent trips involving docking and undocking. The results show all vessels with crewmembers subject to chemical testing, including SPVs, have even lower Post-Accident drug test positivity rates than SPVs exclusively.

Crewmembers subject to comprehensive chemical testing generally have much more to lose than crewmembers on CFVs. A positive drug test will generally result in loss of employment, at least in a safety sensitive position, as well as loss of credentials.

As pointed out in Mehay and Pacula (1999), facing job loss would appear to deter use of dangerous drugs as well as alcohol.

I expected crewmembers not subject to comprehensive chemical testing except for Post-Accident would have higher positivity rates in both drugs and alcohol than crewmembers not subject to chemical testing. Not being subject to comprehensive chemical testing except for Post-Accident drugs and alcohol coupled with the inherent dangerousness of commercial fishing would also seem to result in higher drug and alcohol positivity rates. The inherent dangerousness of commercial fishing is also more likely to attract crewmembers that are more inclined to embrace risk and possibly engage in risky behavior, including drugs and alcohol, compared to crewmembers of small passenger vessels or other vessels with crewmembers subject to chemical testing.

Research question number two is “[t]o what extent, if any, does chemical testing reduce the potential for marine casualties related to drug and alcohol use.” In response to that question this study showed yearly 2003-2011 ratios of Post-Accident positive drug tests per SMI from SPV crewmembers subject to chemical testing are substantially lower than corresponding Post-Accident positive drug tests per SMI from CFV crewmembers not otherwise subject to chemical testing. The differences in Post-Accident positive drug tests per SMI between the two categories are statistically significant and not due to chance; therefore, I rejected the null hypothesis that there are no differences in positive drug tests between the two categories.

This author was surprised to learn the differences between the two categories of crewmembers were at least 20% (2006) and as much as 96% (2009) lower for small passenger vessel crewmembers. I knew small passenger vessel crewmembers subject to comprehensive chemical testing would have fewer Post-Accident positive drug tests per serious marine incident but I did not know that the differences would average 71%. This is especially so because fewer drug related accidents may not necessarily be directly attributed to drug testing but might have occurred due to other improvements in safety, even in the absence of drug testing (Rothstein, 1991). However, with differences this large and statistically significant, being subjected to Pre-Employment, Random, and Reasonable Cause chemical testing would appear to be major influences in those differences.

In further response to research question number two, this study showed yearly 2003-2011 ratios of Post-Accident positive alcohol tests per serious marine incident from small passenger vessel crewmembers subject to chemical testing are substantially lower than corresponding Post-Accident alcohol tests per serious marine incident from commercial fishing vessel crewmembers not otherwise subject to chemical testing. The differences in Post-Accident positive alcohol tests per serious marine incident between the two categories are statistically significant and not due to chance; therefore, I rejected the null hypothesis that there are no differences in positive alcohol tests between the two categories.

For the reasons expressed above concerning the differences in alcohol tests between the two categories, this author was surprised to learn that Post-Accident positive alcohol tests per SMI were at least 8% (2007) and as much as 100% (2006, 2008, and 2010) lower for SPVs from 2003-2011. SPV crewmembers subject to comprehensive chemical testing had a 2003-2011 average of 73% fewer Post-Accident positive alcohol tests per SMI than CFV crewmembers not subject to comprehensive chemical testing.

Also, for the reasons expressed above concerning positive drug tests per SMI, fewer alcohol related accidents may not necessarily be directly attributed to alcohol testing but might have occurred due to other improvements in safety, even in the absence of alcohol testing (Rothstein, 1991). However, with differences this large and statistically significant, being subjected to Pre-Employment, Random, and Reasonable Cause chemical testing as well as the alcohol testing requirements of 33 C.F.R. pt. 95 and the threat of suspension and revocation proceedings for violations of the National Driver Register Act, 49 U.S.C. 30304(a)(3)(A) would appear to contribute to the differences.

Research question number three is, "[t]o what extent, if any, does chemical testing enhance the safety of the maritime transportation industry." In response to research question number three this study showed a strong linear relationship between yearly 2003-2011 Post-Accident drug test positivity rates from all vessels with crewmembers subject to chemical testing and decreasingly lower Random drug test positivity rates for 2003-2011 from all vessels with crewmembers subject to chemical testing; therefore, I rejected the null hypothesis that there is no strong correlation or linear relationship between Random and Post-Accident positivity rates.

This author was aware that Pre-Employment, Random, and Post-Accident positivity rates were gradually trending downward by simply observing the year after year positivity rates. These downward trends are also consistent with the Quest Diagnostics Drug Testing Index (2012) and the 2008 DOD Survey of Health Related Behaviors Among Active Duty Military. I knew there was a moderate to strong correlation between Random and Post-Accident drug test positivity rates but was surprised to learn there was also a linear relationship showing Random positivity rates to be a good predictor of Post-Accident positivity rates.

As discussed above, Pre-Employment drug tests screen out most dangerous drug users. Those remaining are aware they are subject to an unannounced Random test, a Reasonable Cause test, and, if there is a serious marine incident, a Post-Accident drug and alcohol test. As shown graphically in the Figure 6 histogram, it stands to reason that those remaining crewmembers would avoid using dangerous drugs compared to those subject to the Pre-Employment test.

B. CONCLUSIONS

Through secondary data analysis of archived test results, this author examined the extent chemical testing has discouraged drug and alcohol use by commercial vessel personnel, reduced the potential for marine casualties related to drug and alcohol use, and enhanced the safety of the maritime transportation industry. To determine the extent chemical testing has discouraged drug and alcohol use, I examined Post-Accident drug and alcohol positivity rates from two groups of commercial vessel personnel. One group had been subject to chemical testing and the other group had not except for Post-Accident drugs and alcohol. The results showed Post-Accident drug and alcohol positivity rates from the group subject to chemical testing was significantly lower than those from the group not subject to chemical testing except for Post-Accident.

The results also show the extent to which chemical testing has the potential to reduce marine casualties related to drug and alcohol use because the group subject to chemical testing had significantly fewer Post-Accident positive drug and alcohol tests per serious marine incident than the group not subject to chemical testing, except for Post-Accident.

Finally, these results illustrate the extent to which chemical testing has the potential to enhance the safety of the maritime transportation industry. These results showed a strong correlation between Random and Post-Accident drug test positivity rates. Further, a linear regression analysis demonstrated Random positivity rates to be a fairly accurate predictor of Post-Accident positivity rates. Maritime transportation safety is enhanced to the extent of fewer positive chemical tests per serious marine incident.

A. RECOMMENDATIONS

These results suggest chemical testing might discourage drug and alcohol use, reduce the potential for marine casualties, and enhance the safety of the maritime transportation industry. Routine and wide dissemination of these results to the maritime community could further enhance the safety of the maritime transportation industry. Dissemination could simply take the form of displaying positivity rate trends and Post-Accident positive drug and alcohol tests per SMI.

Future studies can encompass crewmembers of all vessel types as well as crewmembers of specific vessel categories. Researchers could include specific drugs (e.g., marijuana, cocaine, PCP, opiates, and amphetamines) and examine the trends in that drug's use as well as the number of positive tests of that drug per SMI in which tests are reported for crewmembers of specific vessel categories. A researcher could also use questionnaires in future studies. Questionnaires designed to ensure anonymity can be made available to commercial vessel personnel at the time they renew their Credentials. The questions can inquire into similar acts and practices as those asked in "Department of

Defense Surveys of Health Related Behaviors Among Active Duty Military" but focus on acts and practices that relate to vessel safety.

This study showed statistically significant differences in Post-Accident positivity rates and positive tests per serious marine incident between small passenger vessel crewmembers and commercial fishing vessel crewmembers. It also showed Random drug tests are good predictors of Post-Accident tests. When combined with current initiatives to enhance commercial fishing vessel safety (Dickey, 2012), comprehensive chemical testing of commercial fishing vessel crewmembers could help reduce the potential for marine casualties related to drug and alcohol use and enhance fishing vessel safety.

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