United States Government Accountability Office

Report to Congressional Committees

May 2017

NAVY FORCE STRUCTURE

Actions Needed to Ensure Proper Size and Composition of Ship Crews

GAO-17-413

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GAO Highlights

Highlights of GAO-17-413, a report to congressional committees

Why GAO Did This Study

In 2001, the Navy began reducing crew sizes on surface ships through an initiative called optimal manning, which was intended to achieve workload efficiencies and reduce personnel costs. In 2010, the Navy concluded that this initiative had adversely affected ship readiness and began restoring crew sizes on its ships.

The conference report accompanying the National Defense Authorization Act for Fiscal Year 2016 included a provision that GAO review the Navy's reduced manning initiatives in the surface fleet. This report examines (1) any trends in ship operating and support costs and maintenance backlogs, (2) the extent to which the Navy's manpower requirements process accounts for ship workload, and (3) any manning challenges and implications for the future.

GAO analyzed and reviewed data from fiscal years 2000 through 2015 (the most current available) on crew sizes, operating and support costs, material readiness, and the Navy's manpower requirements determination process. GAO also interviewed Department of Defense (DOD) officials and ship crews to discuss workload, manning levels, enablers of smaller crew size, and implications for the future.

What GAO Recommends

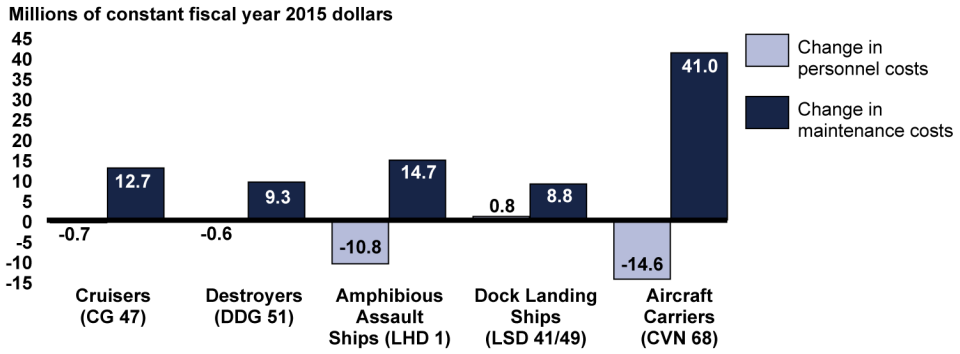
GAO is making four recommendations that the Navy (1) reassess the standard workweek, (2) require examination of in-port workload, (3) require reassessment of the factors used to develop manpower requirements, and (4) identify the personnel costs needed to man a larger fleet. DOD concurred with each recommendation.

View GAO-17-413. For more information, contact John Pendleton at (202) 512-3489 or pendletonj@gao.gov.

What GAO Found

Total ship operating and support costs—which include personnel and maintenance costs—and maintenance backlogs increased during the optimal manning period (2003–2012) and have continued to increase for most ship classes since the initiative ended. Since the implementation of optimal manning, the Navy reduced crew sizes, which decreased the associated personnel costs for most ship classes, even as crews were partially restored. However, increased maintenance costs offset the reductions in personnel costs, as shown below. Navy officials attributed maintenance cost increases to reduced crews, longer deployments, and other factors. GAO's analysis did not isolate the relative effects of reduced crews from these other factors. Maintenance backlogs also increased during the optimal manning period and have continued to grow.

Changes in Average Annual Personnel and Maintenance Costs from Start of Optimal Manning Period through Fiscal Year 2015



Source: GAO analysis of Navy data. | GAO-17-413

The Navy's process to determine manpower requirements—the number and skill mix of sailors needed for its ships—does not fully account for all ship workload. The Navy continues to use an outdated standard workweek that may overstate the amount of sailor time available for productive work. Although the Navy has updated some of its manpower factors, its instruction does not require reassessing factors to ensure they remain valid or require measuring workload while ships are in port. Current and analytically based manpower requirements are essential to ensuring that crews can maintain readiness and prevent overwork that can affect safety, morale, and retention. Until the Navy makes needed changes to its factors and instruction used in determining manpower requirements, its ships may not have the right number and skill mix of sailors to maintain readiness and prevent overworking its sailors.

Moving forward, the Navy will likely face manning challenges as it seeks to increase the size of its fleet. The fleet is projected to grow from its current 274 ships to as many as 355 ships, but the Navy has not determined how many personnel will need to be added to man those ships. In addition, as the Navy has gained experience operating its new ship classes, their crew sizes have grown and may continue to do so. Without updating its manpower factors and requirements and identifying the personnel cost implications of fleet size increases, the Navy cannot articulate its resource needs to decision makers.

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Abbreviations

CG	cruiser
DOD	Department of Defense
CVN	aircraft carrier
DDG	destroyer
LCS	littoral combat ship
LHD	amphibious assault ship
LPD	amphibious transport dock
LSD	dock landing ship
OPNAV	Office of the Chief of Naval Operations
VAMOSC	Visibility and Management of Operating and Support Costs system

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Congressional Committees

The Navy began an initiative in 2001—referred to as optimal manning—to reduce crew sizes aboard various legacy surface and amphibious ships by gradually reducing the required number of crew members.[1] In implementing this initiative, which was intended to achieve workload efficiencies and drive down costs, the Navy reduced the number of sailors required to operate the ships. In 2002, the Navy also made changes to its manpower factors and assumptions, which contributed to reductions in crew sizes. However, we found in 2010 that the Navy had implemented these manning reductions without sufficient analysis.[2] We recommended that the Navy validate the factors and assumptions it used to calculate manpower requirements. The Navy agreed with our recommendation, but as of May 2017, has not fully implemented it.

In a 2010 review of the surface fleet, the Navy found that it had reduced shipboard and shore-based manning to a level that was insufficient to allow the surface fleet to meet minimal standards of material readiness.[3] Between 2010 and 2014, the Navy ended the optimal manning initiative and partially restored crew sizes on its legacy ships. Although the Navy had found that the optimal manning initiative had a detrimental effect on the readiness of legacy ships, it designed its newest surface ship classes to have smaller crews than predecessor ships. The Navy established lower crew size goals for these ships and attempted to reduce their crew sizes by relying to varying degrees on new technologies, automation, and shore support to execute workloads normally completed by larger crews.

Conference Report 114-270, accompanying a bill for the National Defense Authorization Act for Fiscal Year 2016, included a provision for us to review matters related to the Navy's reduced manning initiatives.[4]

[1]Legacy surface and amphibious ships within our scope include aircraft carriers (CVN 68–class), destroyers (DDG 51–class), cruisers (CG 47–class), amphibious assault ships (LHD 1–class), and dock landing ships (LSD 41/49–classes).

[2]GAO, *Military Readiness: Navy Needs to Reassess Its Metrics and Assumptions for Ship Crewing Requirements and Training*, GAO-10-592 (Washington, D.C.: June 9, 2010).

[3]U.S. Navy, Fleet Review Panel, Final Report, *Fleet Review Panel of Surface Force Readiness* (Feb. 26, 2010).

[4]H.R. Conf. Rep. No. 114-270, at 745-746 (2015).

This report discusses (1) any trends in legacy ship operating and support costs, including personnel and maintenance costs, and maintenance backlogs, since the implementation of reduced manning initiatives; (2) the extent to which the Navy's manpower requirements process fully accounts for ship workload; and (3) the challenges, if any, for manning the surface fleet and implications for the future.

To describe trends in operating and support costs for legacy surface and amphibious ships, and maintenance backlogs, we analyzed annual data from fiscal years 2000 (1 year before the Navy began optimal manning) through 2015 (the latest full year for which data were available at the time of our review) from the Navy's cost-reporting system.[5] To describe trends in maintenance and ship material condition, we analyzed data and reviewed documentation on maintenance backlogs, casualty reports, and inspection results from 2000 through 2015. We assessed the reliability of these data and found them to be reliable for the purposes of describing trends and making comparisons for ship crew sizes, operating and support costs, shore support personnel, and ship material condition. Specifically, we reviewed our prior work making use of these data, and interviewed Navy officials with knowledge of the data and reviewed documentation on the data and related systems.[6] Where possible, we also corroborated the data with other data sources. To describe the Navy's process for determining manpower requirements (the size and composition of ship crews and shore-based support units), we analyzed Navy policies and procedures for determining crew sizes on surface and amphibious ships as well as various studies and reports on the Navy's manpower requirements process, including on its factors and assumptions.[7] We also interviewed officials from multiple Navy offices and met with officers and enlisted personnel from two destroyers and two

[5]Ship operating and support costs include the costs of operating, maintaining, and supporting a ship, including personnel, operations, maintenance, sustainment, and modernization.

[6]GAO, *Navy Force Structure: Sustainable Plan and Comprehensive Assessment Needed to Mitigate Long-Term Risks to Ships Assigned to Overseas Homeports*, GAO-15-329 (Washington, D.C.: May 29, 2015).

[7]Department of Defense (DOD) Directive 1100.4, *Guidance for Manpower Management* (Feb. 12, 2005); Office of the Chief of Naval Operations Instruction (OPNAVINST) 1000.16L, *Navy Total Force Manpower Policies and Procedures* (June 24, 2015) (change transmittal 1, Apr. 28, 2016); Under Secretary of Defense for Personnel and Readiness Memorandum, *Interim Policy and Procedures for Strategic Manpower Planning and Development of Manpower Estimates* (Dec. 10, 2003).

amphibious transport dock ships, and with crew members from both variants of the littoral combat ship, to discuss crew workload, size, and composition. To describe the Navy's challenges for manning the surface fleet and implications for the future, we analyzed Navy plans and reports and interviewed program officials and ship crews. Our scope and methodology is described in detail in appendix I.

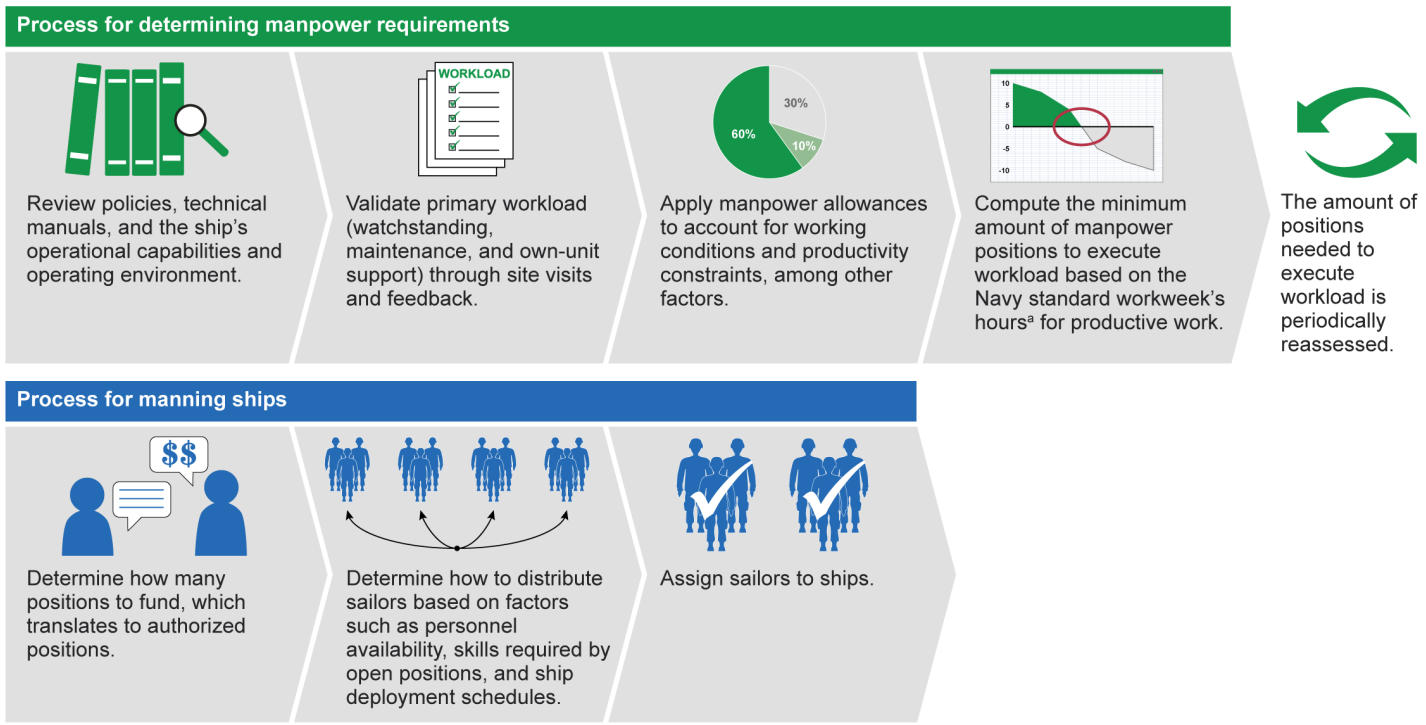
We conducted this performance audit from March 2016 to May 2017 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Ship Manpower Requirements and Manning

The Navy determines the number of sailors and the skills needed to operate its ships through a standardized manpower requirements process. The Navy then mans the ships by filling the required positions—to the extent that the number and type of positions are funded and the trained and qualified personnel are available to fill them—as summarized in figure 1.

Figure 1: Navy Processes for Determining Manpower Requirements and Manning Ships



Source: GAO analysis of Navy information. | GAO-17-413

[a]The Navy standard workweek is the total 168 hours in a week divided into components with associated time allowances. A sailor has a specific number of hours allocated under each component to perform primary duties such as productive work (watchstanding and maintenance), but also for sleep, eating meals, and for personal needs. The time allowance for productive work is 70 hours per week for military personnel at sea. The number of hours allocated for productive work is used to translate the total weekly work hours into manpower requirements.

This manpower requirements process is based primarily on the documents that lay out a ship class's required operational capabilities and projected operational environment (i.e., the missions the ship will fulfill and how it will operate to carry them out).[8] The Navy Manpower Analysis Center is the chief agent in determining manpower requirements by validating a ship's primary workload; applying allowances to account for working conditions, among other factors; and computing the manpower requirements—the number and mix of positions needed to meet the

[8]Required Operational Capabilities and Projected Operating Environment documents detail the capabilities required of ships in various operational situations and the environment in which the ship is expected to operate, including the military climate.

Navy's operational expectations. The Navy Manpower Analysis Center develops manpower requirements for new ship classes either after a ship's first deployment or about 1 year after the ship has become operational, and publishes the validated requirements in Ship Manpower Documents.[9] Navy Manpower Analysis Center officials reassess a ship's manpower requirements to ensure that they are up to date every 5 years or after major capability upgrades, changes to allowances, or other changes. After the manpower requirements are determined for a ship, the Navy mans the ship by filling the required positions to the extent that the number and type of positions are funded, and the trained and qualified personnel are available to fill them. After the budgeting and sailor distribution process, a ship's manning level may be lower than the manpower level that the manpower requirements process has determined was needed. The process by which manpower requirements are determined for shore-based personnel is described in appendix II.

Reduced Manning Initiatives

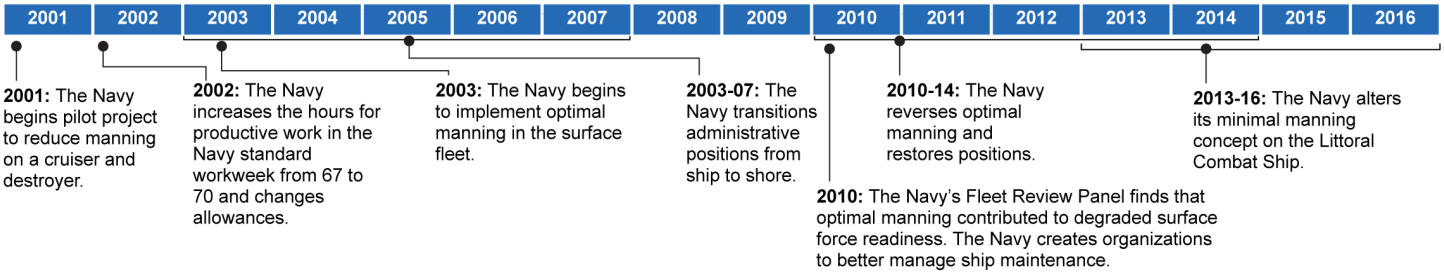
The Navy has tried several ways to reduce the size of ship crews in order to reduce costs. The optimal manning initiative, introduced as a pilot program on a cruiser and destroyer in 2001 and implemented fleet-wide on other surface and amphibious ships beginning in 2003, was intended to improve efficiency. Initially, optimal manning levels were often derived by changing watchstanding requirements.[10] As an example, the number of watchstanders required to serve as battle station phone operators and stretcher bearers was reduced, and, as a result, 10 positions were removed from ships with these positions. Other watchstations were consolidated or eliminated. Between 2003 and 2007, the Navy transferred some administrative workload from ship to shore personnel, which further reduced the size of ship crews. This corresponding effort, known as Pay and Personnel Ashore, had the effect of moving two-thirds of the

[9]Until new ship classes have operational experience, which is used to develop formal manpower requirements, the Navy relies on preliminary manpower requirements estimated by Navy acquisition programs. Preliminary manpower requirements follow manpower standards and procedures and are documented in preliminary ship manpower documents.

[10]The Navy has a number of positions that must be filled in order to maintain the safety and security of its ships. These positions are referred to as watchstations, and Navy personnel fill these positions on a rotational basis, typically standing watch for 4 to 6 hours at a time. The numbers and types of watches vary depending on whether the ship is under way or in port. For example, a ship that is in port will require more security watchstanders, while a ship that is under way will require navigation watchstanders who are not needed in port.

personnel specialist positions responsible for these administrative functions from ship crews to shore support units.[11] To further drive down ship crew sizes, the Navy changed workload assumptions and the equation used to determine manpower requirements in 2002. For example, it increased the Navy standard workweek from 67 to 70 productive hours per sailor, which further reduced shipboard manning by up to 4 percent. A time line of reduced manning initiatives that were implemented from 2001 to 2016 is included in figure 2.

Figure 2: History of Reduced Manning Initiatives



Source: GAO analysis of Navy information. | GAO-17-413

In addition to reducing crew sizes on legacy ships through the means described, the Navy also designed its newest ship classes to operate with smaller crew sizes, relying on new technologies, automation, and shore support to enable these reductions. Profiles of new ship classes designed to operate with reduced crew sizes are included in appendixes III, IV, V, and VI.

Actions Taken in Response to Lessons Learned from Optimal Manning

As noted in the Navy's 2010 Fleet Review Panel report, a primary lesson of the optimal manning period is that using unvalidated assumptions to reduce crews contributed to the erosion of the material condition of the fleet.[12] In response to these findings, the Navy has partially restored crew sizes on its legacy ships and has increased the size of shore units to better support its ships (see app. VII for information on shore support personnel). In addition, the Navy took several other steps to address the declining material condition of the surface fleet, such as the following:

[11]Net decreases ranged from 4 positions transferred from destroyer crews to 28 positions from amphibious assault ship crews.

[12]Fleet Review Panel, *Fleet Review Panel of Surface Force Readiness*.

- Establishing the Surface Maintenance Engineering Planning Program in 2010 to provide centralized life-cycle maintenance engineering for surface ships, maintenance and modernization planning, and management of maintenance strategies. The Navy also established the Commander, Navy Regional Maintenance Centers (CNRMC) in 2010, to coordinate the depot- and intermediate-level maintenance of its surface fleet. The goal of these efforts is to improve the material condition and readiness of the surface fleet and to adhere to a more disciplined deployment and maintenance schedule. Navy officials told us that, as a result of these initiatives, the Navy has developed a better understanding of its ships' material condition and maintenance needs, and maintenance requirements have generally increased.
- Creating the Surface and Expeditionary Warfare Training Committee in 2013, which is to inform leadership of surface manpower and training investments, resourcing, acquisition, and execution. Officials said that program offices for new ships are now required to annually update manpower estimates and adjust manpower requirements based on lessons learned.
- Introducing a revised operational schedule known as the Optimized Fleet Response Plan in 2014, which was intended, among other things, to provide for the predictable scheduling of ship maintenance tasks and ensure that ship crews were manned with a sufficient number of sailors with the right qualifications.[13]

[13]For more information on the Optimized Fleet Response Plan, see GAO, *Military Readiness: Progress and Challenges in Implementing the Navy's Optimized Fleet Response Plan*, GAO-16-466R (Washington, D.C.: May 2, 2016).

Ship Operating and Support Costs and Maintenance Backlogs Have Continued to Increase for Most Legacy Ship Classes since Optimal Manning Ended

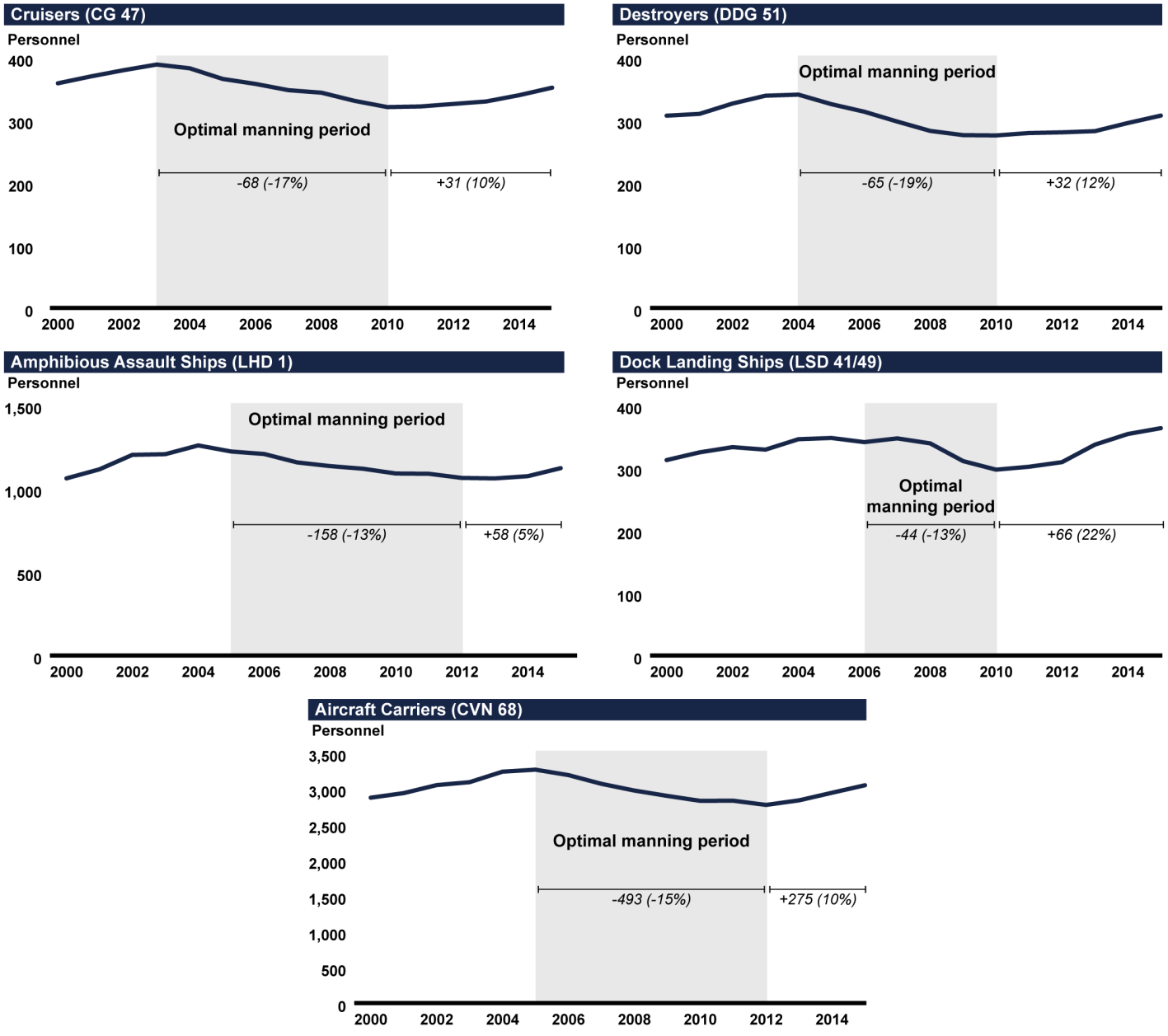
Ship operating and support costs—the total cost of operating, maintaining, and supporting a ship, including personnel, operations, maintenance, sustainment, and modernization—increased during the optimal manning period and have continued to increase for most ship classes, in part because increases in maintenance costs offset reductions in personnel costs.[14] Since the end of the optimal manning period around 2010, the Navy has partially restored crew sizes, and personnel costs have increased for all ship classes. In addition, maintenance costs have increased for some ship classes and decreased for others, although maintenance costs are still above pre–optimal manning levels for all ship classes. Navy officials attributed maintenance cost increases to reduced crews, longer deployments, and other factors. Maintenance backlogs also increased during the optimal manning period for the same reasons and have continued to grow for most ship classes.

The Navy Has Partially Restored Crew Sizes since Optimal Manning Ended, and Personnel Costs Have Increased

During the optimal manning period—which varied among ship classes but generally was around fiscal years 2004 to 2010—the Navy reduced average crew sizes, as shown in figure 3, resulting in reductions in personnel costs. Since the end of optimal manning, the Navy has increased crew sizes, leading to increases in associated personnel costs. However, the crews and associated personnel costs for all ship classes—with the exception of dock landing ships (LSD 41/49–classes)—are still smaller than they were before the optimal manning initiative, in part because the Navy has retained the longer 70-hour workweek component for productive work that it had adopted during the optimal manning period, which results in a requirement for fewer crew members.

[14]For additional information on ship operating support costs, see app. VIII.

Figure 3: Average Crew Size by Ship Class, Fiscal Years 2000–2015, Including Changes and Percent Changes in Crew Size during and after the Optimal Manning Period

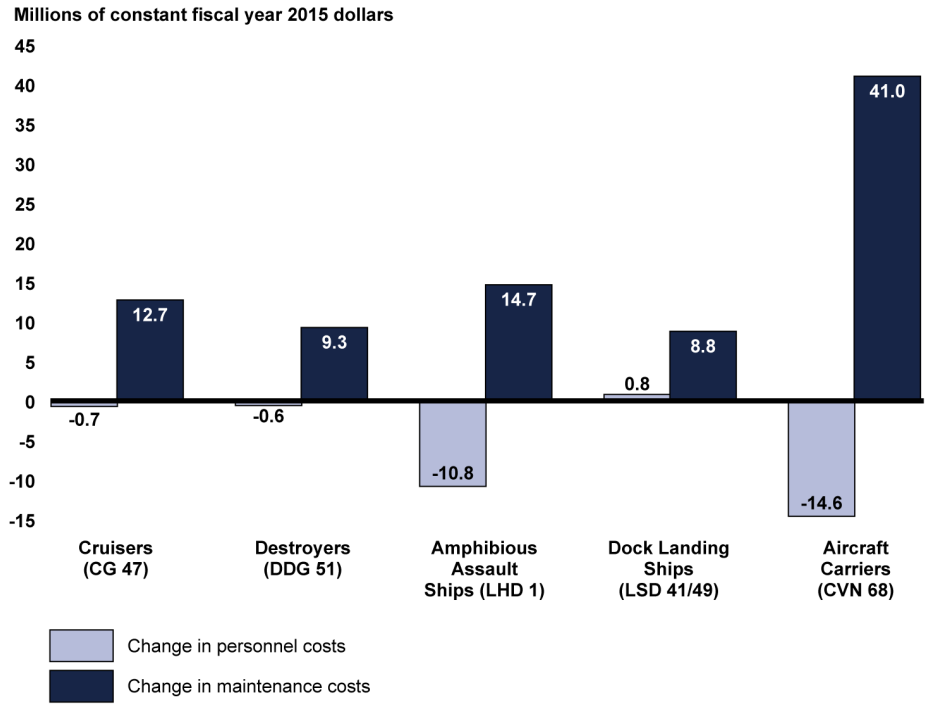


Source: GAO analysis of Navy data. | GAO-17-413

Maintenance Costs Increased during Optimal Manning and Have since Continued to Increase for Some Ship Classes

Our analysis found that, at the same time that the Navy reduced crew sizes and personnel costs, average maintenance costs per ship increased for all ship classes. These increases more than offset the decreases in personnel costs that were achieved during the optimal manning period. Since the Navy ended the optimal manning initiative, the change in maintenance costs has varied; maintenance costs continued to increase for cruisers and destroyers, but have decreased for aircraft carriers, amphibious assault ships, and dock landing ships. In all cases, maintenance costs are above pre–optimal manning levels, as shown in figure 4. Further, our analysis found that overall operating and support costs increased for all classes during the optimal manning period and have continued to increase for most ship classes since optimal manning ended. This increase was driven in part by increases in maintenance costs offsetting decreases in personnel costs.

Figure 4: Changes in Average Annual per Ship Personnel and Maintenance Costs from Start of Optimal Manning through Fiscal Year 2015



Source: GAO analysis of Navy data. | GAO-17-413

Note: Total change from start of optimal manning period is calculated as the change in the average annual cost for a ship class from the pre–optimal manning level to fiscal year 2015, including both the optimal manning period and the post–optimal manning period. The optimal manning period varied among ship classes. For the purpose of our analysis, we determined the optimal manning period for each ship class to be as follows: aircraft carriers (CVN 68) and amphibious assault ships (LHD 1),

2005 to 2012; dock landing ships (LSD 41/49), 2006 to 2010; cruisers (CG 47), 2003 to 2012; and destroyers (DDG 51), 2004 to 2010.

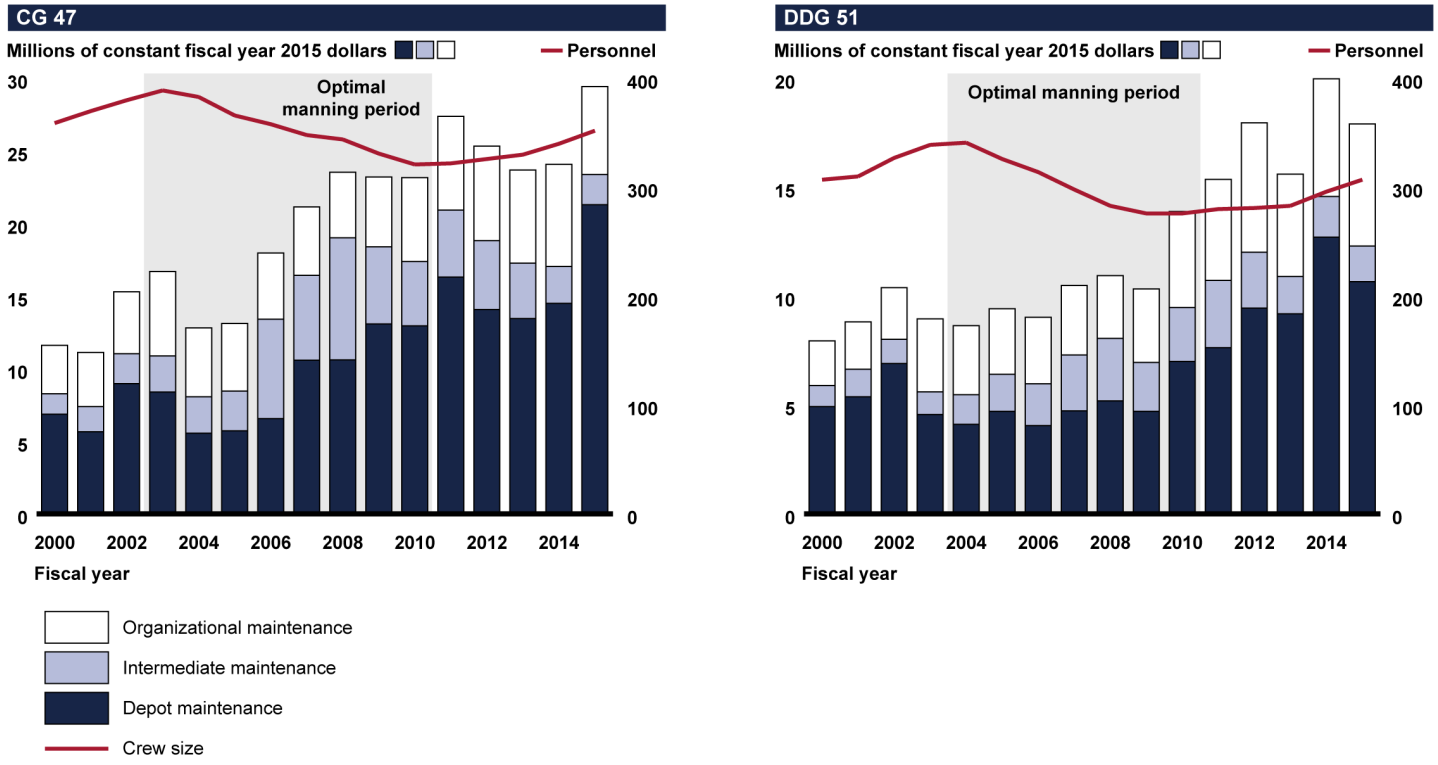
Navy officials acknowledged that the reduced crew sizes during the optimal manning period, along with reductions in shore support, may have yielded short-term cost savings, but also increased maintenance costs over the longer term, in part because reduced crew sizes resulted in maintenance being deferred, which developed into more costly issues that had to be addressed later. Navy officials also attributed increases in maintenance costs to increased deployment lengths, increased reliance on contractors to perform maintenance, and some class-specific maintenance and modernization efforts. Other factors, such as the age of a ship, may also affect maintenance costs. Our analysis does not isolate the effects of these factors from the effect of the optimal manning initiative.

Increased Reliance on Depot and Contractor Maintenance Increased Costs during and since Optimal Manning

Navy officials told us that shifts from organizational- and intermediate-level to depot-level maintenance increased overall maintenance costs. As noted above, this change occurred in part because reduced crew sizes resulted in minor maintenance being deferred, which developed into more costly issues that had to be addressed later at the depot level.[15] Our analysis of Navy maintenance costs found that intermediate-level maintenance costs increased for most classes during the optimal manning period, and depot-level maintenance costs increased for all classes, as shown in figures 5 and 6. Depot maintenance costs have continued to increase for most classes and are above pre–optimal manning levels for all classes as of fiscal year 2015.

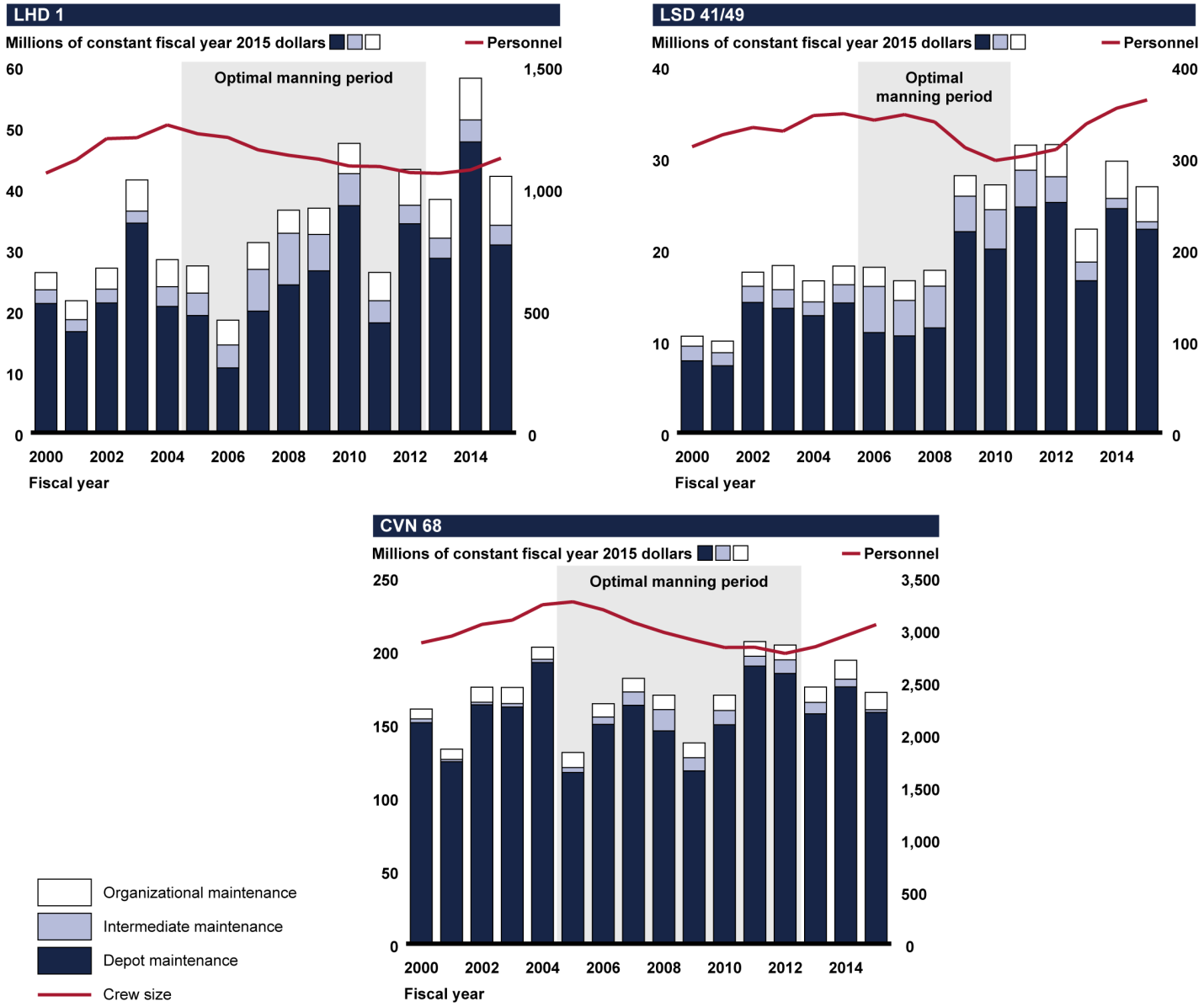
[15]Organizational-level maintenance is performed by a ship crew and normally consists of routine preventive work such as inspecting, servicing, and replacing parts. Intermediate-level maintenance is performed by shore support units, including contractors, and consists of work such as calibration, repair, or replacement of damaged or unserviceable parts, and providing technical assistance to operators. Depot-level maintenance is performed at private and public shipyards and typically consists of major overhaul, modification, and rebuild of ship components. Organizational-level maintenance costs include the cost of parts and other materials but does not include the cost of labor, and therefore may understate the full cost of organizational maintenance. Intermediate- and depot-level maintenance costs include the cost of labor as well as parts and other materials.

Figure 5: Average Organizational-, Intermediate-, and Depot-Level Maintenance Costs and Ship Crew Sizes for Cruisers (CG 47) and Destroyers (DDG 51), Fiscal Years 2000–2015



Source: GAO analysis of Navy data. | GAO-17-413

Figure 6: Average Organizational-, Intermediate-, and Depot-Level Maintenance Costs and Ship Crew Sizes for Amphibious Assault Ships (LHD 1), Dock Landing Ships (LSD 41/49), and Aircraft Carriers (CVN 68), Fiscal Years 2000–2015



Source: GAO analysis of Navy data. | GAO-17-413

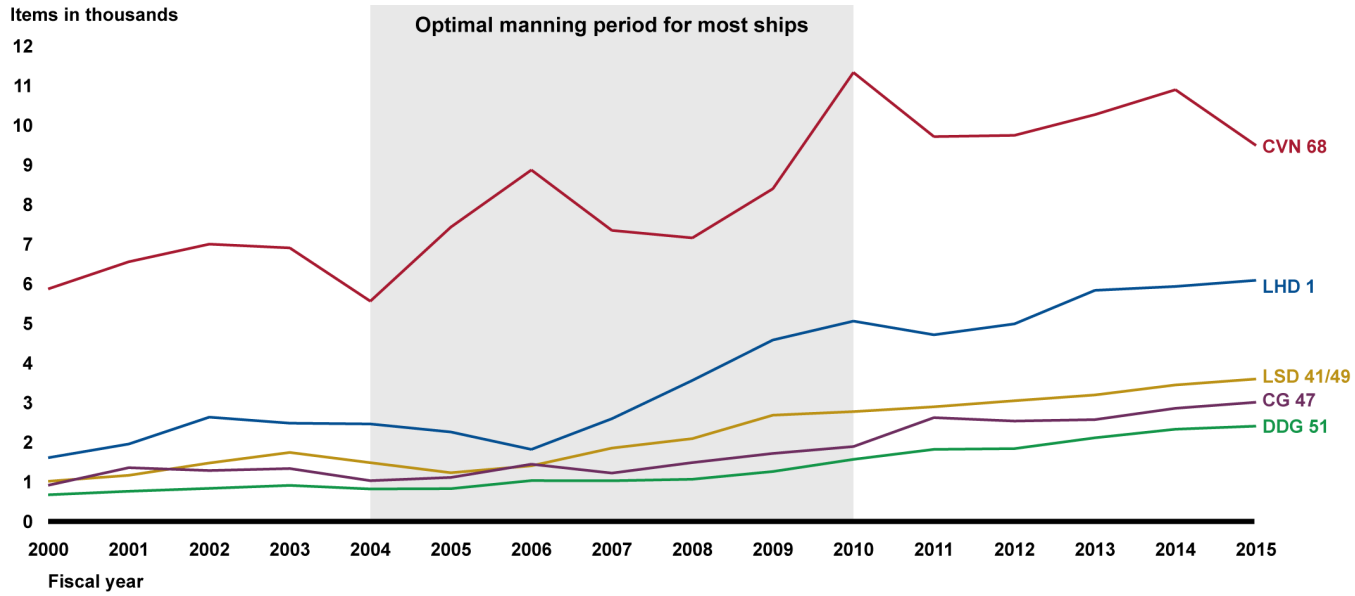
Navy officials also acknowledged that reduced manning is enabled by an increased reliance on outside entities, such as contractors, to perform maintenance. Our analysis found that the cost of maintenance performed by contractors and in private shipyards increased for all ship classes during the optimal manning period and has continued to increase for most ship classes since crew sizes were restored. However, increases in contractor costs have been driven primarily by the increase in depot-level maintenance. The Navy generally contracts with private shipyards and other firms for the repair, maintenance, and modernization of nonnuclear surface ships.[16] Private shipyards and contractors are generally focused on depot-level maintenance, and are responsible for most depot-level maintenance. As a result, increases in depot-level maintenance have driven increases in contractor maintenance costs. Contractor maintenance costs at the intermediate level decreased for most classes during the optimal manning period and have continued to decrease for most classes in the period since.

Both Maintenance Backlogs and Equipment Malfunctions Increased during Optimal Manning and Have Continued to Increase

The Navy's 2010 Fleet Review Panel found that reduced manning prevented ship crews from performing the minimum required level of preventive maintenance, resulting in a growing maintenance backlog—a measure of the deferred maintenance for a particular ship—as well as increased equipment malfunctions (i.e., casualty reports). Navy officials have also acknowledged that the reduced crew sizes during the optimal manning period, along with increased deployment lengths, contributed to decreases in the material condition and readiness of ships. Our analysis of Navy maintenance backlog data found that backlogs increased for all ship classes during the optimal manning period, as shown in figure 7. While increases in backlogs were occurring before the optimal manning initiative, these increases accelerated during the optimal manning period for most ship classes. Since optimal manning ended, backlogs have continued to increase for most ship classes, but the rate of increase has slowed for most classes. Although Navy officials told us that reductions in manning can affect maintenance backlogs, they have not quantified the magnitude of that relationship.

[16]These contractors constitute what is referred to as the ship repair industrial base. Although the Navy operates several government-owned shipyards, those shipyards are generally used to support the repair, maintenance, and modernization of nuclear powered ships, such as submarines and aircraft carriers.

Figure 7: Average Maintenance Backlog by Ship Class, Fiscal Years 2000–2015



Source: GAO analysis of Navy data. | GAO-17-413

Note: The optimal manning period varied among ship classes. For the purpose of our analysis, we determined the optimal manning period for each ship class to be as follows: aircraft carriers (CVN 68) and amphibious assault ships (LHD 1), 2005 to 2012; dock landing ships (LSD 41/49), 2006 to 2010; cruisers (CG 47), 2003 to 2012; and destroyers (DDG 51), 2004 to 2010.

The Fleet Review Panel also noted that casualty reports increased during the optimal manning initiative.[17] Our previous work found that casualty reports continued to increase following the end of optimal manning. In 2015, we found that casualty reports had nearly doubled for cruisers, destroyers, and amphibious ships between January 2009 and July 2014.[18] According to Navy officials, their initiatives to improve ship material condition are beginning to make progress, and Navy documentation we reviewed shows that the numbers of surface ship casualty reports decreased between July 2014 and December 2016. Another measure of ship material readiness, the Board of Inspection and

[17]Casualty reports include information on individual pieces of equipment or systems on a ship that are degraded or out of service, preventing a ship's ability to support required mission areas.

[18]GAO-15-329.

Survey's Figure of Merit Scores, has generally improved since the Navy ended the optimal manning initiative.[19]

The Navy's Manpower Requirements Process Does Not Account for All Ship Workload

The Navy has updated some of the factors it uses to determine the manpower required on its ships, but its process does not fully account for all ship workload. The Navy continues to use the workweek standard adopted during the optimal manning period, which increased the hours for productive work from 67 to 70 hours a week. This change was part of what enabled the Navy to reduce crew sizes. However, a 2014 Navy study indicated that this standard may be outdated. Although the Navy has updated some manpower factors, its guidance on total force manpower policies and procedures, Office of the Chief of Naval Operations (OPNAV) Instruction 1000.16L, does not require that these factors be reassessed to ensure that they remain current and that ship crews are sized appropriately.[20] Further, the Navy's manpower requirements process does not account for growing in-port workload, which is distributed among fewer crew members than when ships are at sea.

The Navy Has Updated Some Manpower Factors but Continues to Use an Outdated Workweek Standard

Since it ended the optimal manning initiative, the Navy has updated or is in the process of updating several of the factors and allowances it uses to determine manpower requirements on all ships, but it has not updated the standard workweek. In 2012, the Navy Manpower Analysis Center studied the "make ready / put away" allowance, which accounts for the time needed to prepare and close out of a maintenance activity. The center recommended increasing the allowance from 15 percent to 30 percent of the total preventive maintenance man hours on a ship, and the

[19]The Board of Inspection and Survey is responsible for inspecting Navy ships and reporting on their readiness. As a result of its inspections, the board assigns ships an overall inspection score—the Figure of Merit—which is a single-number representation of the ship's overall material condition and represents a ranking of material condition relative to other ships. The score ranges from 0 to 1, with higher scores representing better overall material condition. According to Board officials, changes to the inspection criteria in 2003 resulted in an increase in scores from 2004 onward. As a result, we did not compare Figure of Merit scores from before the optimal manning period to those during the optimal manning period.

[20]OPNAVINST 1000.16L. This instruction requires periodic review of fleet and shore-based manpower requirements, but not for the factors that are used to calculate those requirements. This instruction also requires the periodic review of shore manpower requirements. See appendix II for details about the manpower requirements determination process for shore support.

Navy began implementing this change in 2013. Navy manpower officials found that, over the years, changes to regulations, instructions, and basic safety requirements had increased the time it takes for sailors to perform duties associated with this allowance. In addition, the Office of the Chief of Naval Operations directed Navy manpower officials to update the productivity allowance, which accounts for delays arising from fatigue and work interruptions, among other factors. They increased the allowance from a range between 2 and 8 percent of productive work requirements to a range between 2 and 20 percent for selected ship classes.[21] This change to the productivity allowance accounts for a new measure of mental fatigue associated with monitoring technology. The Navy is examining other factors—the corrective maintenance allowance, ship aging factors, and its pay-grade distribution model. Table 1 shows the status of the factors in the Navy manpower requirements model.

[21]The Office of the Chief of Naval Operations, Total Force Manpower, Training and Education Requirements, has the authority to issue additional policy and technical guidance to achieve the objectives of the Navy total force manpower policies and procedures. The Navy changed this allowance for CG 47, DDG 51, LHD, LPD, and LSD ships.

Table 1: Status of Factors and Allowances Used in the Navy Manpower Requirements Model for Ships

Factor	Definition	Status as of February 2017
Hours in a week allotted for work		
Navy Standard Workweek	The number of hours per week available to accomplish the required workload while a ship is under way	In 2002, the Navy increased the amount of time it expects sailors to carry out productive work each week from 67 to 70 hours without conducting required analysis.[a] In fiscal year 2014, the Navy studied the components of the workweek, but has not addressed the study's recommendations. Navy officials and crew members we spoke with suggested that the workweek should be reassessed.
Working conditions and productivity constraints that add to workload		
Make Ready / Put Away Allowance	The amount of time it takes to prepare for the execution of a preventive maintenance task and the time it takes to return the items used to execute the task	In 2002, the Navy reduced this allowance without required analysis from 30 to 15 percent of the total preventive maintenance man hours required on the ship.[b] In 2012, the Navy assessed the allowance, and in 2013 restored it to 30 percent. The Navy is in the process of updating manpower requirements based on this change.
Productivity Allowance	Reflects delays arising from fatigue, environmental effects, personal needs, and unavoidable interruptions that increase the time required to complete work	In 2002, the Navy reduced this allowance without required analysis from a uniform 20 percent of productive work requirements to a floating range up to 8 percent. In 2016, the Navy assessed and altered the allowance to a range of up to 20 percent for selected ship classes.[c] The allowance varies between ship classes, and Navy officials told us that it has yet to be updated for all ship classes, which is contingent on resources being available. The Navy is in the process of updating manpower requirements for the ships affected by the allowance change.
Corrective Maintenance Allowance	Reflects unscheduled maintenance conducted in response to malfunction, failure, or deterioration	The allowance for corrective maintenance is a ratio of the time allowed for preventive maintenance. The Navy is currently reexamining this allowance.
Ship aging factors	The number of years a ship has been operating (to account for the different needs of newer and older ships)	This factor was established in 2001, is currently in use for developing manpower requirements, and is under further development.
Distribution of work among pay grades		
Pay-grade distribution models	The distribution of pay grades to perform the workload	The Navy is currently reexamining these models.

Source: GAO analysis of Navy information. | GAO-17-413

[a]GAO, Military Readiness: Navy Needs to Reassess Its Metrics and Assumptions for Ship Crewing Requirements and Training, GAO-10-592 (Washington, D.C.: June 9, 2010).

[b]Ibid.

[c]The Navy changed this allowance for cruisers (CG 47), destroyers (DDG 51), amphibious assault ships (LHD), amphibious transport docks (LPD), and dock landing ships (LSD).

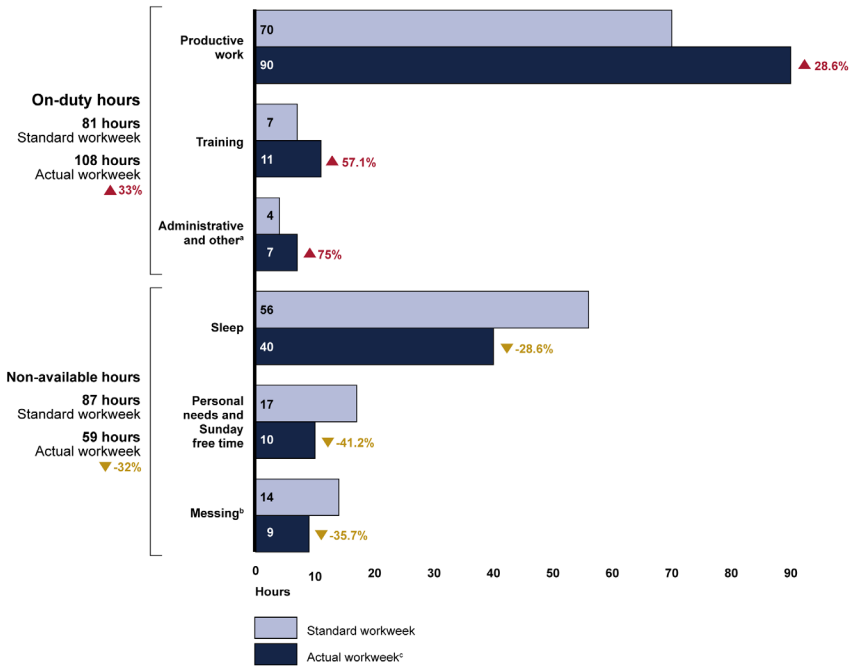
Although the Navy has updated several of its manpower factors, it has not made any changes to the standard workweek that it adopted during the optimal manning period. In 2002, the Navy changed the portion of the standard workweek allocated for sailors to perform productive work, which is used, in part, to determine manpower requirements and calculate the size of the crew.[22] By increasing the time allotted for productive work in a standard workweek, the Navy reduced the number of personnel on its surface and amphibious ships. In 2010, we found that the Navy had adjusted the workweek without sufficient analysis, and we recommended that it reassess the standard workweek to assure that the Navy was appropriately sizing ship crews.[23] The Department of Defense (DOD) agreed with our recommendation. In 2014, the Navy conducted a study of the standard workweek and identified significant issues that could negatively affect a crew's capabilities to accomplish tasks and maintain the material readiness of ships, as well as crew safety issues that might result if crews sleep less to accommodate unaccounted for workload.

The Navy study found that sailors were on duty 108 hours a week, exceeding their weekly on-duty allocation of 81 hours. This on-duty time included 90 hours of productive work—20 hours per week more than the 70 hours that is allotted in the standard workweek. This, in turn, reduced the time available for rest and resulted in sailors spending less time sleeping than was allotted, a situation that the study noted could encourage a poor safety culture. Figure 8 shows how sailors actually spent their time compared to the time allotted for each component in the Navy standard workweek, as reported in the Navy's 2014 study.

[22]When the Navy adjusted the workweek in 2002, it held the sailor's total on-duty hours constant at 81 hours but increased productive work from 67 to 70 hours and reduced time allotted for administrative activities from 7 to 4 hours.

[23]GAO-10-592.

Figure 8: Comparison between Navy Standard Workweek and Actual Hours Spent per Component



Source: GAO analysis of Navy information. | GAO-17-413

[a]"Administrative and other" accounts for administrative tasks and other activities that are required of sailors, including inspections and receiving medical attention, among other things.

[b]Messing refers to the time taken for meals.

[c]Actual hours represent data collected from three ship crews based on how sailors spent their previous 24 hours, which was then multiplied by 7 to attain weekly estimates. In the study, sailors reported spending about 2 actual hours in an additional "Other" category for time spent outside of the predetermined categories. The actual workweek does not add up to 168 hours because of rounding numbers.

An example of work that is not accurately accounted for in the workweek is time spent by experienced personnel providing on-the-job training or time spent by new arrivals receiving this training. Navy manpower calculations do not include on-the-job training, and it is not accounted for in the 7 hours allocated for training in the standard workweek. Navy officials and crew members we interviewed told us that sailors often arrive to their assigned ship without adequate skills and experience. Crew members in 10 of the 12 crew interviews we conducted told us that more experienced sailors routinely provide on-the-job training for less experienced sailors, so the time doing this must come out of sleep, personal time, or other allotted work time. In addition, Navy officials said that the time allocated for administrative and other duties should be

greater, because it does not account for all of a sailor's collateral duties. Similarly, the 2014 Navy study concluded, among other things, that the Navy lacked support for the time needed for some workweek components, and recommended that they be better supported by documentation.

However, as of February 2017, the Navy had not taken action to validate the standard workweek, as we and its own study had recommended. Navy officials said that they had not taken any action in response to the 2014 study's recommendations because the study's narrow scope of three ships limited its applicability across the fleet. OPNAV Instruction 1000.16L specifies the total time available to accomplish the required workload, which is a key element in the calculation of manpower requirements.[24] According to the Navy instruction, the process for determining the manpower necessary to perform the required workload is to be based on a validated and justifiable technique; that is, it should be analytically based. Without an analytically based standard workweek that accounts for all of the work that a sailor is expected to do, the Navy runs the risk of negatively affecting the condition of the ship, overworking sailors, and adversely affecting morale, retention, and safety.

The Navy instruction does not require the factors used to develop ship manpower requirements to be reassessed periodically or when conditions change.[25] The effect of this absence is that inaccurate factors can persist in developing manpower requirements. Factors and allowances are used to calculate manpower requirements; thus, if these factors are inaccurate, the resulting manpower requirement will be inaccurate. Our prior work found that the changes the Navy made to several of these factors in 2002 were not substantiated with analysis.[26] As a result, the Navy was using these unsubstantiated factors for at least a decade without reassessment, leading it to underestimate its manpower requirement and underman its ships, and the Navy found that reductions in crew sizes over the optimal manning period adversely affected ship condition. Prior to recent reassessments of the make ready / put away allowance and productivity allowance, some factors had not been reassessed and updated in decades—even though there had been changes to how the Navy trains,

[24]OPNAVINST 1000.16L.

[25]Ibid.

[26]GAO-10-592.

operates, and uses technology that affected the validity of these factors. Navy officials told us that part of the reason they had not reassessed the factors until directed to do so is that the relevant Navy instruction does not require that they be reassessed periodically or when conditions change, and they explained that having up-to-date factors would be useful to ensure that sailor workload could be accurately captured.[27] If there was a requirement to reassess these factors, then the unsubstantiated changes made to them in 2002 may have been corrected sooner and some of the negative effects of the resulting undermanned crews could have been curtailed or avoided. Additionally, a reassessment requirement could prevent inaccurate factors like the standard workweek from continuing to be used across the fleet. The Navy estimated in 2017 that if it were to revert to the analytically based standard workweek in effect before 2002, more than 1,200 additional sailors would be required across the surface fleet.

A memorandum from the Under Secretary of Defense for Personnel and Readiness states that, when developing strategic manpower plans, manpower officials shall assess how changes to roles, missions, and management strategies will affect workloads and require a change to the manpower, and that manpower officials shall be consulted concerning manpower adjustments, including changes to missions, priorities, and technologies.[28] DOD Directive 1100.4 states that it is DOD policy that new policy shall be evaluated before implementing to decide its effect on manpower and personnel performance. The directive further states that existing policies, procedures, and structures shall be periodically evaluated to ensure efficient and effective use of manpower resources.[29] Unless the OPNAV instruction used by the Navy to develop its manpower requirements requires that the factors be reassessed periodically or when conditions change, the Navy manpower requirements model will not reflect changes in training, technology, or regulations that occur over time and that affect sailor workload. Requiring that these factors be reassessed periodically or when conditions change would help ensure

[27]Navy manpower officials told us that their capacity to carry out periodic reassessments is limited by their staff size and data collection capacity—that, as of January 2017, the Navy Manpower Analysis Center had 101 personnel, with about 15 staff members available for surface ship data collection.

[28]Under Secretary of Defense for Personnel and Readiness Memorandum, *Interim Policy and Procedures for Strategic Manpower Planning and Development of Manpower Estimates* (Dec. 10, 2003).

[29]DOD Directive 1100.4, *Guidance for Manpower Management*.

that they are accurate and current, and result in more accurate manpower requirements. Without accurate manpower requirements, the Navy risks having ship crews that are not appropriately sized and composed to carry out missions, maintain ship readiness, and prevent overwork of sailors.

The Navy's Manpower Requirements Process Does Not Account for In-Port Workload

OPNAV Instruction 1000.16L calls for measuring only a ship's at-sea workload and not its in-port workload. The Navy has traditionally assumed that at-sea workload is greater. However, we reported in 2010 that in-port workload had increased for a number of reasons, including the addition of new watchstanding requirements for Anti-Terrorism Force Protection.[30] We recommended that the Navy include the relative magnitude of in-port and at-sea workload in its assessment of the underlying assumptions and standards it uses to calculate manpower requirements, and DOD agreed with this recommendation.

During our current review, we found that in-port workload is still not captured in the process and is a persistent problem for crews, who must complete this workload with fewer sailors than when at sea, and whose time is also in demand for addressing other in-port priorities. The Navy has not measured in-port workload and therefore cannot determine the manpower requirements needed to execute this workload. Navy operational capability documents describe the in-port period as the time for the crew to accomplish required maintenance; take maximum advantage of training; and be provided the maximum opportunity for rest, leave, and liberty. Officers and enlisted personnel from all 12 of the crew interviews we conducted told us that sailors were overworked in port. Sailors consistently said that there were fewer crew members in port than during deployment, because sailors were attending training and taking leave, or because the Navy was prioritizing the manning of ships on deployment over ships in port. For example, one ship department had 5 crew members while in port compared with 10 to 12 crew members during deployment, so workload had to be redistributed among the remaining sailors. In addition, sailors from a supply department said that their workloads on the ship were the same when in-port and when on

[30]The Navy has Anti-Terrorism Force Protection watchstanding requirements to reduce the effect of terrorist and other security threats that threaten U.S. naval vessels worldwide. This is accomplished by implementing certain security watches, criteria, and practices. The duty of the security watches is to safeguard the ship and ship's company from sabotage, terrorism, civil disturbance, danger, or compromise. Emphasis is directed toward antiterrorism measures designed to protect vessels in port or at anchorage.

deployment, but there were fewer sailors available in port to execute the workloads. As in our 2010 review, crew members cited Anti-Terrorism Force Protection watchstanding requirements as creating additional training and work demands on them, and added that standing these watches in port comes at the expense of their other work. Both officers and enlisted personnel told us that ship crews are stressed and overburdened during in-port periods because they must stand watch and cover the workload of multiple sailors. Crew members told us that when they returned from deployment, this additional workload placed a strain on them and their families, affecting crew member morale.

During the course of our review, in December 2016, Navy manpower officials began a study on the nature and amount of in-port workload; they are scheduled to complete this study in July 2017. The Navy directed the in-port workload study to inform development of its new training initiative, known as Ready Relevant Learning, to begin implementation in fiscal year 2017.[31] However, Navy officials are still uncertain how this new approach to training will be managed, and officials have expressed concerns about its potential effects on in-port workload and the effects of having sailors who are not fully trained arrive for duty on their assigned ships.

Although the Navy is currently in the process of measuring in-port workload, officials said that there are no efforts planned to use the study results to translate in-port workload into manpower requirements, and that a future determination will be made as to the implementation of any results of the study. OPNAV Instruction 1000.16L requires that the Navy determine at-sea manpower requirements, but does not require the Navy to determine—nor does it have a formal process or protocol to model—in-port manpower requirements. Without identifying the manpower needed to execute in-port workload, the Navy risks overworking its sailors during in-port periods and having this workload executed without the appropriate number and mix of sailors, which in turn may affect ship readiness, safety, and sailor morale.

[31]Under the Ready Relevant Learning initiative, the Navy plans for sailors to receive training in phased blocks during in-port periods instead of completing their initial training qualifications all at once.

The Navy May Be Challenged to Man Its Growing Fleet

Moving forward, the Navy will likely face manning challenges, especially given its current difficulty in filling authorized positions, as it seeks to increase the size of its fleet as much as 30 percent over its current size. Moreover, new ship classes being introduced now are sometimes requiring more personnel than originally estimated as the Navy gains experience with the ships. Navy officials stated that even with manpower requirements that accurately capture all workload, the Navy will be challenged to fund these positions and fill them with adequately trained sailors at current personnel levels.

Increasing Fleet Size May Exacerbate Manning Challenges

Even with the reduced personnel authorized since optimal manning, the Navy has had difficulty filling authorized personnel slots, called "billets" in the Navy. The Navy's commands responsible for manning, equipping, and training the surface fleet have cited the lack of personnel available to be distributed to ships as their primary challenge. Unfilled positions on ship crews and in shore support positions result in workload that must be redistributed among the remaining crew and also represent skills and abilities that are absent from a crew, exacerbating the risks associated with smaller authorized crews. Officials said that it is not uncommon for billets to remain unfilled for 6 months or more and that shore commands are more likely to experience such "gapped billets" for even longer periods.

A 2014 Naval Audit Service report examined critical gapped billets, based on a concern that shortfalls among senior enlisted personnel made it impossible to meet shipboard manning requirements.[32] The report found that the Navy has taken actions to reduce gapped billets, but the issue persists. As a result, gapped billets continue to exist, sailors may be required to work longer hours to make up for gapped billets, and junior sailors may not be receiving needed supervision. The report concluded, among other things, that unless the Navy increases enlisted personnel, recurring gaps will not be corrected.

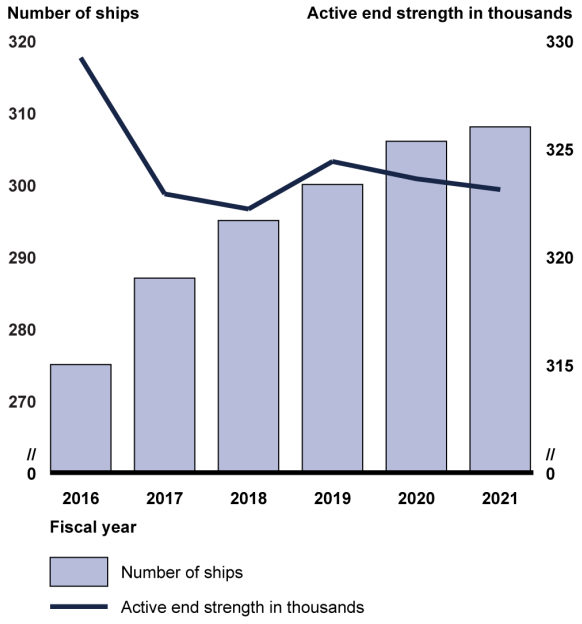
Given the continued demand for ships to support combatant commanders, the Navy plans to increase its fleet from 274 ships (as of March 7, 2017) to 308 ships by 2021.[33] As of March 2017, the Navy had

[32]Naval Audit Service, *Fleet Gapped Critical Billets*, N2014-0022 (Washington, D.C.: May 20, 2014).

[33]This plan to increase the size of the fleet is included in the Fiscal Year 2017 Shipbuilding Plan.

an end strength of 323,197 active-duty personnel. According to the Navy, this number is expected to remain largely flat through 2021, even though an increasing number of ships are entering the fleet. Navy officials have expressed concern about the growing gap between end strength and ship numbers, and said that the Navy would have to increase its end strength in order to adequately man its ships. Figure 9 shows the Navy's projected end strength and fleet size.

Figure 9: Planned Number of Navy Ships and Projected Personnel End Strength



Source: GAO analysis of Navy data. | GAO-17-413

Note: Number of ships from 2017 to 2021 is based on the 308-ship fleet size in the Navy's Fiscal Year 2017 shipbuilding plan. The Navy has not yet updated its shipbuilding plan to reflect its new goal of 355 ships. Projected personnel end strength is the total number of active-duty personnel in the Navy.

The Navy has also identified the need for an even larger fleet, which would add to personnel needs and costs. Specifically, the Navy released an updated Force Structure Assessment in late 2016 that called for a 355-ship fleet to meet global threats—a 15 percent increase from the previous 308-ship goal and a 30 percent increase from the size of its current fleet.[34] In a February 2017 report, the Congressional Research Service estimated the additional shipbuilding costs that would be needed

[34]As of March 7, 2017, the fleet contained 274 battle force ships.

over a 30-year period based on the Force Structure Assessment, but added that these additional shipbuilding funds are only part of what would be needed to achieve and maintain a 355-ship fleet instead of 308-ship fleet.[35] According to DOD, operating and support costs—which include personnel and maintenance costs—have traditionally constituted about 70 percent of a ship's total life-cycle costs.[36] Our analysis has shown that personnel costs were the largest share of total operating and support costs for surface ship classes between fiscal years 2000 to 2015 (see app. VIII for total ship operating and support costs).

The underlying cause for this apparent ship–personnel mismatch is that the Navy is seeking to grow its fleet but is not fully assessing the personnel implications of the growth. Navy officials told us that it mans its ships and all other positions within its approved end strength, but has not determined the number or cost of personnel needed to man the increasing number of ships or made concrete plans for adding the needed personnel. The personnel needs will be significant. The Congressional Research Service estimated that about 15,000 additional sailors and aviation personnel might be needed to man the 47 additional ships above the previous 308-ship plan.[37] Plans to grow the fleet further to 355 ships—and our findings that manpower validation processes are based on questionable assumptions that likely understate personnel needs—could further exacerbate the mismatch. However, the Navy has not fully assessed whether the service will need increased end strength and, if so, how much. Navy officials told us that if overall Navy end strength is not increased, the billets would likely have to be taken from other organizations as new ships are delivered, potentially continuing to perpetuate the gapped billets challenge.

Our prior work has shown that identifying needed resources and investments is a key characteristic that helps to establish a comprehensive, results-oriented management framework to guide

[35]Congressional Research Service, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress* (Feb. 2, 2017).

[36]Office of the Secretary of Defense, Cost Assessment and Program Evaluation, *Operating and Support Cost-Estimating Guide* (Mar. 2014).

[37]Congressional Research Service, *Navy Force Structure and Shipbuilding Plans*. GAO reviewed the methodology used to estimate additional sailors and found it to be reasonable.

implementation of plans and strategies.[38] This activity includes identifying what a strategy will cost and the sources and types of resources and investments associated with the strategy. According to Navy officials, in order to compensate for the lack of distributable personnel who would be needed to fill all manpower requirements within the current end strength, they currently prioritize which positions to fill and which to keep unfilled in order to maintain a permissible level of risk and readiness in the surface fleet. As the Navy continues to update ship manpower requirements based on recent changes to the factors and allowances used to calculate them, these requirements are likely to increase. Already-strained manpower resources will be even more stressed as the Navy commissions increasing numbers of ships without a commensurate increase in personnel. Unless it updates its manpower factors and requirements, and identifies the personnel cost implications associated with any planned increases in the fleet size, the Navy will not be positioned to accurately articulate internally within DOD or externally to Congress the personnel needs of the Navy.

Crew Sizes on Recently-Inducted Ship Classes Have Grown as the Navy Gains Experience Operating Them

In addition to using the outdated standard workweek and not accounting for in-port workload, the Navy developed estimates of manpower requirements and crew size targets for its new ships based on assumptions that technologies would enable smaller crews. However, crew sizes on most new ship classes have grown over time as anticipated workload reductions from new technologies have not materialized and the Navy gains more experience operating the new ships.[39] These technologies include networks that integrate ship systems to allow for remote monitoring, redesigned propulsion systems on some ships, and extensive use of automation to relieve crews of some manual work; however, some of these technologies are still not fully developed, tested, or fielded and remain immature. As a result, crew sizes have grown to allow sailors to do this manual work.

[38]See GAO, *Combating Terrorism: Evaluation of Selected Characteristics in National Strategies Related to Terrorism*, GAO-04-408T (Washington, D.C.: Feb. 3, 2004); *Defense Management: Comprehensive Strategy and Annual Reporting Are Needed to Measure Progress and Costs of DOD's Global Posture Restructuring*, GAO-06-852 (Washington, D.C.: Sept. 13, 2006); *Defense Management: More Reliable Cost Estimates and Further Planning Needed to Inform the Marine Corps Realignment Initiatives in the Pacific*, GAO-13-360 (Washington, D.C.: June 11, 2013).

[39]New ships classes with reduced crew size targets include the *Ford*-class aircraft carrier (CVN 78), *Zumwalt*-class destroyer (DDG 1000), Littoral Combat Ship (LCS), and *San Antonio*–class Amphibious Transport Dock (LPD 17).

For example, crew sizes for the Littoral Combat Ship (LCS), *Zumwalt*-class destroyer (DDG 1000), and *San Antonio*–class Amphibious Transport Dock (LPD 17) have increased since these ships entered service, as shown in table 2, and LCS and DDG 1000 have reached the upper limits for crew size as laid out in their acquisition strategies. Navy officials acknowledged that LCS and DDG 1000 crew sizes have grown due to the inadequacy of the original manpower assumptions coupled with additional mission requirements to support ship operations. The new *Ford*-class aircraft carrier (CVN 78) has not yet entered service, and its crew size so far remains within the Navy's targets—currently 663 sailors below that of legacy *Nimitz*-class carriers. However, some planned features of the ship that were expected to reduce workload have been canceled, and delays in developing and testing some of the new technologies on the ship create unknowns about their ability to enable a smaller crew. See appendixes III, IV, V, and VI for specific information on each new ship class.

Table 2: Crew Size Changes for New Ship Classes as of February 2017

Ship class	Initial crew size[a]	Current crew size	Percent change
Ford-class aircraft carrier (CVN 78)[b]	2,628	2,628	0
Zumwalt-class destroyer (DDG 1000)	158	175	+11
Littoral Combat Ship (LCS)	75[c]	98[d]	+31
San Antonio–class amphibious transport dock (LPD 17)	363	378	+4

Source: GAO analysis of Navy information. | GAO-17-413

[a]Initial crew sizes are from Preliminary Ship Manpower Documents.

[b]Crew sizes are for the ship's force—all personnel aboard the carrier except those designated as part of the air wing and in certain support or other assigned roles. An additional 1,912 personnel are expected to embark with the ship in addition to the ship's force.

[c]This figure includes the total initial LCS crew including the core crew of 40, mission module crew of 15, and aviation detachment of 20 personnel.

[d]This figure includes the total current LCS crew including a merged core and mission crew of 70, an aviation detachment of 24, and four ensigns (junior officers) whom the Navy does not consider to be required per Navy manpower analysis but who nonetheless serve as functional members of every LCS crew due to their availability.

The LCS program illustrates how crew size can grow over time as the Navy gains operational experience with the ship class and its new technology. The Navy originally designed and built these ships to accommodate a total crew size of 75, but gradually increased the ships'

crews as it gained more experience operating them, and has since had to redesign the ships to accommodate 98 sailors—a 31 percent increase. As of March 2017, three of the Navy's nine LCS ships have been deployed overseas. Automation and the use of condition-based maintenance have not decreased workload as they were intended to do, and the unreliability of shipboard systems has led to major equipment failures and unanticipated corrective maintenance.[40] Officers and enlisted crew members told us that the LCS's minimally sized crews are challenged to complete their workload. In 2014, we found that the LCS program had a number of manning challenges and that without validating the crew size and composition for all LCS crews and without accounting for the full scope and distribution of work performed by sailors across all ship departments, the Navy risked that crew fatigue would exceed Navy standards and could negatively affect crew members' performance as well as morale, retention, safety, and ultimately the operational readiness of the ship class.[41]

In response to LCS manning and other challenges, the Navy conducted a program review in 2016 and announced changes to the ships' crewing and other operational concepts that are now being implemented across the program.[42] LCS officials told us that some of the program changes are meant to alleviate the heavy workload of LCS sailors. Specifically, the Navy has formed LCS maintenance execution teams to assist with heavy in-port workload, build organic expertise, decrease dependence on maintenance contractors, and serve as a pool of qualified sailors who can fill in for unplanned losses in LCS crews. Officials responsible for implementing program changes told us that they are in the process of

[40]Condition-based maintenance is the process of scheduling maintenance based on actual need through analysis of data from the ship's equipment. The data are obtained in real time or near-real time from sensors embedded in ship components or systems, and then monitored and analyzed ashore.

[41]GAO, *Littoral Combat Ship: Deployment of USS Freedom Revealed Risks in Implementing Operational Concepts and Uncertain Costs*, GAO-14-447 (Washington, D.C.: July 8, 2014).

[42]Original LCS operational concepts called for each ship to have a "core crew" to carry out basic functions like engineering, propulsion, and navigation, and a separate "mission module" crew to carry out one of the three LCS missions. Mission-related equipment and combat systems were to be modular so that the mission package and the crew responsible for operating it could be swapped out of each ship as needed. In 2016, the Navy integrated core crews of 50 and mission module crews of 15–20 into one crew of 70, meaning that there will be more positions in some of the integrated crews than there were before in the core-plus-mission-module crewing construct.

determining the composition of LCS integrated crews, and are using all available inputs and information to determine the best mix of sailors. However, Navy manpower officials have yet to validate these changes to the LCS crewing concept, and delays in LCS mission module development and testing do not allow for them to validate needed crew size and composition since the modules are immature.

Navy officials told us they validate manpower requirements for new ship classes after testing is complete and the first ship of the class has been deployed. Most new ship classes have unvalidated manpower requirements due to lack of operational experience or system immaturity. Table 3 summarizes the status of manpower requirement validation for new ship classes with reduced crews.

Table 3: Status of Manpower Requirements for New Ship Classes and Enablers of Crew Size Reductions

Ship class	Entered service	Manpower requirements validated	Enablers of crew size reductions		
			New technologies	Automation	Shore support
Ford-class aircraft carrier (CVN 78)	Delivery scheduled for 2017 with active service date to be determined	No—awaiting ship delivery, testing, and deployment	Yes	Yes	No
Zumwalt-class destroyer (DDG 1000)	October 2016[a]	No—ship is in testing and no deployment date scheduled	Yes	Yes	Yes
Littoral Combat Ship (LCS)	Variant 2: January 2010 Variant 1: November 2008	Variant 2: No—first of variant currently deployed Variant 1: No— manpower requirement validated for previous manning construct[b]	Yes	Yes	Yes
San Antonio–class amphibious transport dock (LPD 17)	January 2006	Yes	No	Yes	No

Source: GAO analysis of Navy information. | GAO-17-413

[a]Only the ship's hull, mechanical, and electrical systems are in service. Combat systems have not been tested or activated.

[b]The Navy has separate manpower documents for the two LCS variants to account for their significant differences. The Navy Manpower Analysis Center validated the core crew size for one of the two LCS variants in 2015, but the Navy changed the crewing concept for all LCS ships in September 2016.

As noted above, crew sizes on three of the Navy's four new ship classes have grown partly because the technologies in use have not led to the expected reductions in workload. In the case of LCS and LPD 17, the lack of physical space limits the ability of the crews to grow further without

significant redesign of ship interiors. The DDG 1000 crew has reached its upper crew size target, but program officials have said that the ship could accommodate additional sailors as the ship gains more operational experience—if it is determined that they are necessary.[43] CVN 78 crews may also grow until technologies meant to reduce workload and crew sizes mature. Until technologies on new ships are mature and demonstrate their ability to decrease workload, crew sizes on new ships may continue to grow, placing further pressure on the Navy's resources.

Conclusions

During the optimal manning period of the early 2000s, the Navy made changes to its manpower requirements process that were intended to drive down crew sizes and thus save on personnel costs. However, these changes were not substantiated with analysis. The result was that with fewer sailors operating and maintaining surface ships, the material condition of the ships declined, and this effect ultimately contributed to increased overall operating and support costs. The Navy has reassessed and reversed some of the changes it made during the optimal manning period, but it continues to use a workweek standard that does not reflect the actual time sailors spend working, and the Navy still does not account for in-port workload—both of which may be leading to sailors being overworked and creating a readiness and safety risk. In addition, the Navy's guidance does not require that the factors used to calculate manpower requirements be reassessed periodically or when conditions change to ensure that these factors remain valid and crews are appropriately sized. A requirement to reassess these factors would help ensure that they stay current and analytically based, and would provide the Navy a sound basis for its manpower requirements. Looking to the future, the Navy plans to grow its fleet as much as 30 percent but has not determined how many personnel will be needed to man the larger fleet or what these personnel will cost. As the number of ships increases—and if crew sizes continue to grow on new ship classes—the Navy will be challenged to distribute its sailors across the fleet without an increase in personnel. Unless it identifies the personnel needs and costs associated with a larger fleet size, the Navy runs the risk of buying ships that it cannot fully man, potentially repeating the mistakes associated with the optimal manning period and resulting in degraded surface fleet readiness and increased maintenance costs.

[43]Although the ship has entered active service, DDG 1000 combat systems have not been activated or tested.

Recommendations for Executive Action

To ensure that the Navy's manpower requirements are current and analytically based and will meet the needs of the existing and future surface fleet, we recommend that the Under Secretary of Defense for Personnel and Readiness direct the Secretary of the Navy to have the Navy take the following four actions:

- conduct a comprehensive reassessment of the Navy standard workweek and make any necessary adjustments;
- update guidance to require examination of in-port workload and identify the manpower necessary to execute in-port workload for all surface ship classes;
- develop criteria and update guidance for reassessing the factors used to calculate manpower requirements periodically or when conditions change; and
- identify personnel needs and costs associated with the planned larger Navy fleet size, including consideration of the updated manpower factors and requirements.

Agency Comments

We provided a draft of this report to DOD for review and comment. In its comments, reproduced in appendix IX, DOD concurred with our recommendations, citing its commitment to ensuring that the Navy's manpower requirements are current and analytically based and will meet the needs of the existing and future surface fleet. DOD also provided technical comments, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees; and to the Secretary of Defense; the Under Secretary of Defense for Personnel and Readiness; and the Secretary of the Navy. In addition, the report is available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-3489 or pendletonj@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report are listed in appendix X.

John Pendleton
Director
Defense Capabilities and Management

List of Committees

The Honorable John McCain
Chairman
The Honorable Jack Reed
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Thad Cochran
Chairman
The Honorable Richard J. Durbin
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Mac Thornberry
Chairman
The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable Kay Granger
Chairwoman
The Honorable Pete Visclosky
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Scope and Methodology

To describe trends in Navy crew sizes and operating and support costs on its legacy ships, we analyzed annual data from fiscal years 2000 through 2015 (the most current data available at the time of our review) from the Navy's Visibility and Management of Operating and Support Costs (VAMOSC) system. We included all classes and flights of surface ships that were (1) in service during the optimal manning period, (2) subject to crew size reductions during that period, and (3) still in service as of fiscal year 2015. The following ship classes and flights were included in our analysis:

- *Nimitz*-class (CVN 68) Aircraft Carriers;
- *Arleigh Burke*–class (DDG 51) Destroyers (including Flights I, II, and IIA);[1]
- *Ticonderoga*-class (CG 47) Cruisers;
- *Wasp*-class (LHD 1) Amphibious Assault Ships;[2] and
- *Whidbey Island*– (LSD 41) and Harpers Ferry–class (LSD 49) Dock Landing Ships.[3]

As noted in our report, the years of the optimal manning period varied among ship classes. To determine the optimal manning period for each class, we analyzed Navy documentation and data on crew levels for each ship class. Based on this analysis, we defined the optimal manning period as the following for each class, and used these years in our analyses of changes during the optimal manning period:

- *Nimitz*-class (CVN 68) Aircraft Carriers: fiscal years 2005–2012;
- *Arleigh Burke*–class (DDG 51) Destroyers (including Flights I, II, and IIA): fiscal years 2004–2010;
- *Ticonderoga*-class (CG 47) Cruisers: fiscal years 2003–2010;

[1]For analysis and reporting purposes, we used the weighted average crew sizes and operating and support costs for all three destroyer flights.

[2]Based on discussions with Navy Sea Systems Command, we excluded the USS Makin Island (LHD 8) from our analysis. This decision was based on the fact that (1) the ship had a different propulsion system from other *Wasp*-class ships, and is effectively its own class, and (2) the ship was commissioned during fiscal year 2010, and therefore was not in service for the majority of the optimal manning period.

[3]For analysis and reporting purposes, we used the weighted average crew sizes and operating and support costs for both classes of dock landing ships.

- *Wasp*-class (LHD 1) Amphibious Assault Ships: fiscal years 2005–2012; and
- *Whidbey Island*– (LSD 41) and Harpers Ferry–class (LSD 49) Dock Landing Ships: fiscal years 2006–2010.

For our analysis, we used the following elements in the VAMOSC database:

- Crew size: "Number of Personnel—Navy."
- Total operating and support costs: all cost elements.
- Personnel costs: all cost elements within "Unit-Level Manpower."
- Maintenance costs: all costs elements within "Maintenance":
  - Organizational-level maintenance: "Consumable Materials and Repair Parts" and "Depot Level Repairables."
  - Intermediate-level maintenance: all cost elements within "Intermediate Maintenance."
  - Depot-level maintenance: all costs elements within "Depot Maintenance."
  - Maintenance performed by private shipyards and contractors: "Intermediate-Level Contractor Maintenance," all cost elements for private shipyards within "CNO-Scheduled Depot Maintenance," and all cost elements for private shipyards within "Fleet Depot Maintenance."
- Other operating and support costs: all costs elements within "Unit Operations," "Sustaining Support," and "Continuing System Improvements."

We reviewed trends in these elements for each ship class in our scope. We also calculated the change in each element during and since the optimal manning period, as well as the total change since the beginning of the optimal manning period, for each ship class in our scope, as described below:

- change during optimal manning period is calculated as the change in dollars and percent from the pre–optimal manning level and the last year of optimal manning for a ship class;
- change since optimal manning period is calculated as the change in dollars and percent from the last year of optimal manning for a ship class and fiscal year 2015; and

- total change since start of optimal manning period is calculated as the change in dollars and percent from the pre–optimal manning level for a ship class and fiscal year 2015.

To describe maintenance and ship material condition trends, we analyzed maintenance backlog, casualty report, and inspection result data from 2000 through 2015, as specified below:

- For maintenance backlog data, we requested data on the number of maintenance backlog items for each ship in our scope and calculated class and type averages of the number of maintenance backlog items as of September 30 of each fiscal year. To analyze the change in maintenance backlogs in the pre–optimal manning, optimal manning, and post–optimal manning periods, we compared the average annual rate of change in the number of backlog items for each ship type during each period, as defined above for each ship class.
- For casualty report data, we reviewed Navy reports and other documentation, as well as our prior work, which reported on trends in casualty reports during the optimal manning and post–optimal manning periods.[4]
- For inspection report data, we compared average scores for the Board of Inspection and Survey's Figure of Merit for the optimal manning and post–optimal manning periods for each ship type. According to board officials, changes to the inspection criteria in 2003 resulted in an increase in scores from 2004 onward. As a result, we did not compare Figure of Merit scores from before the optimal manning period to those during the optimal manning period.

We assessed the reliability of the Navy's VAMOSC, maintenance backlog, casualty report, and inspection report data and found them to be reliable for the purposes of describing trends and making comparisons over time in ship crews, operating and support costs, shore support personnel, and material conditions. Specifically, we reviewed prior GAO reports making use of these data, interviewed Navy officials with knowledge of the data, and reviewed documentation on the data and related systems. Where possible, we also corroborated the data with other data sources.

[4]GAO, *Navy Force Structure: Sustainable Plan and Comprehensive Assessment Needed to Mitigate Long-Term Risks to Ships Assigned to Overseas Homeports*, GAO-15-329 (Washington, D.C.: May 29, 2015).

To analyze trends in shore support personnel, we requested that officials from the Office of the Chief of Naval Operations' Expeditionary Warfare (N95), Surface Warfare (N96), and Air Warfare (N98) directorates identify those shore support units that provided support specific to amphibious ships, surface combatants, and aircraft carriers. We then analyzed data from VAMOSC on trends in the number of full-time-equivalent military personnel assigned to these units from fiscal years 2002 to 2015. As part of this analysis, we also analyzed trends in units responsible for training as well as trends in units that are associated with Navy regional maintenance centers.

To assess the extent to which the Navy's manpower requirements process fully accounts for ship workload, we examined the factors and assumptions used in determining crew sizes for surface and amphibious ships, and we analyzed various Navy documents and instructions related to determining crew sizes, including Office of the Chief of Naval Operations Instruction 1000.16L, *Navy Total Force Manpower Policies and Procedures*, in order to identify the steps required in the Navy's process to determine crew sizes.[5] Furthermore, we reviewed prior GAO work on shipboard and shore-based manpower requirements determination,[6] as well as previous Navy studies on the process, including on the sufficiency of its factors. We also interviewed Navy officials to discuss their process in determining manpower requirements, changes to the process (including its factors and allowances) since the end of optimal manning, current studies under way, and the status of the newest ship classes.

We also conducted group discussions with crews from six ships, having separate discussions with officers and enlisted personnel from each ship for a total of 12 group discussions. We met with crews from two destroyers, two amphibious transport dock ships, and both variants of the littoral combat ships (LCS) to discuss crew size, composition, and workload. We selected these ship classes for their years of operational experience as well as their representation of ships subject to different

[5]Office of the Chief of Naval Operations Instruction (OPNAVINST) 1000.16L, *Navy Total Force Manpower Policies and Procedures* (June 24, 2015) (change transmittal 1, Apr. 28, 2016).

[6]GAO, *Military Readiness: Navy Needs to Reassess Its Metrics and Assumptions for Ship Crewing Requirements and Training*, GAO-10-592 (Washington, D.C.: June 9, 2010); and *Force Structure: Streamlining Plans Could Enable Navy to Reduce Personnel Below Fiscal Year 1999 Goal*, GAO/NSIAD-97-90 (Washington, D.C.: Apr. 18, 1997).

reduced manning initiatives: (1) optimal manning initiative (DDG 51), (2) minimal manning construct (LCS), and (3) reduced crew size targets from their predecessor ship classes (LPD 17). Specifically, we visited ship classes homeported in both the Pacific and Atlantic Fleet, which included the USS *Higgins* (DDG 76), USS *Bainbridge* (DDG 96), LCS Crew 101, LCS Crew 203, USS *Anchorage* (LPD 23), and USS *Arlington* (LPD 24). For each visit, we requested to speak with a cross section of personnel from each ship department and carried out group discussions with the officers and enlisted personnel available.

We interviewed officials or obtained documentation at the following locations:

Department of Defense

- Office of the Secretary of Defense
  - Cost Assessment and Program Evaluation
  - Defense Manpower Data Center

Department of the Navy

- Office of the Chief of Naval Operations
  - Force Manpower and Assessments Branch
- U.S. Fleet Forces Command
  - Commander, Naval Surface Force, U.S. Atlantic Fleet
  - Command Manpower Analysis Team
  - Board of Inspection and Survey
- Commander, Naval Surface Force, U.S. Pacific Fleet
  - Commander, Littoral Combat Ship Squadron One
- Naval Sea Systems Command
  - Cost Engineering and Industrial Analysis Division
  - Program Executive Office Aircraft Carriers
  - Program Executive Office Littoral Combat Ships
  - Program Executive Office Ships
  - Surface Maintenance Engineering Planning Program
  - Commander, Navy Regional Maintenance Center

- Naval Center for Cost Analysis
- Naval Education and Training Command
- Bureau of Naval Personnel
  - Naval Personnel Command
  - Navy Manpower Analysis Center
- Navy Safety Center
- Naval Audit Service

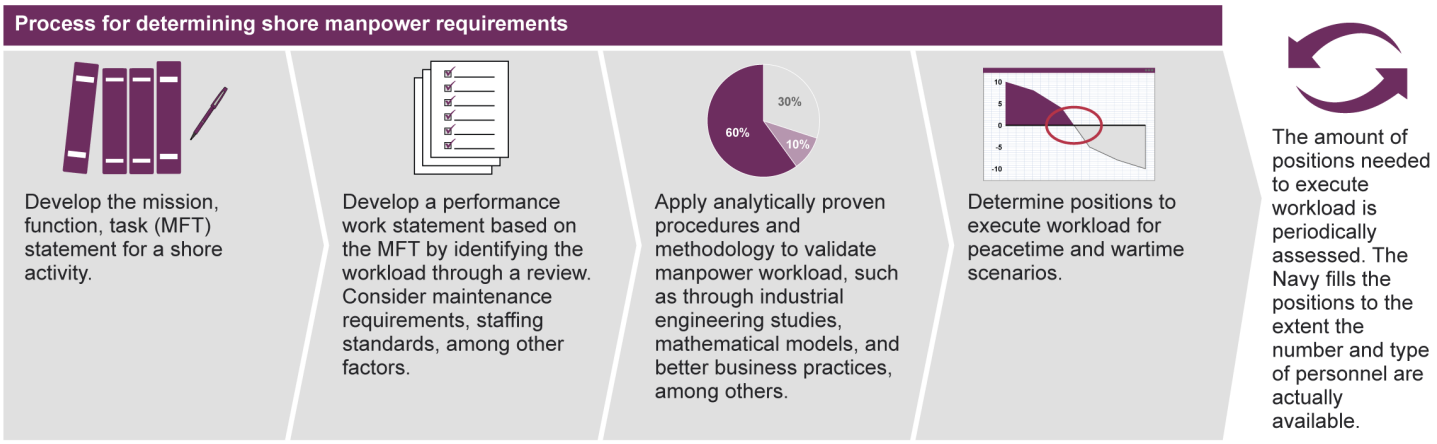
To determine the challenges, if any, for manning the surface fleet and implications for the future, we analyzed the Navy's 2017 30-year Shipbuilding Plan, 2016 Force Structure Assessment, and 2017 Department of Navy budget. We also reviewed and analyzed reports on manpower and manning by the Center for Naval Analyses, Naval Audit Service, Congressional Research Service, and GAO. We also analyzed acquisition, manpower, and operational documents to determine the crew size goals and current crew sizes for new ship classes. We interviewed program and other Navy officials to discuss the status of new technologies, manning challenges, and crew sizes growth on new ships. We also interviewed Navy officials and ship crews to discuss fleet-wide manpower and manning challenges.

We conducted this performance audit from March 2016 to May 2017 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Shore Support Manpower Requirements Process

The Navy has a decentralized process for determining its shore support manpower requirements. Each of the 20 major shore commands is the primary agent for determining and approving the scope of their activities, whether they are personnel, training, and maintenance functions or activities like research and development. The major shore commands cover multiple warfighting enterprises and providers, such as U.S. Fleet Forces Command, U.S. Pacific Fleet, Naval Sea Systems Command, and others. This process is illustrated in figure 10.

Figure 10: Navy Process for Determining Shore Manpower Requirements



Source: GAO analysis of Navy information. | GAO-17-413

The major shore command or activity[1] writes the mission, functions, and tasks (MFT) statement, which is the primary document for identifying the shore activity's workload. Each major shore command provides its own analysts with training to conduct manpower reviews for various activities. These analysts draw from the MFT statement to develop a performance work statement that identifies the work to be done. In determining manpower requirements, analysts also consider maintenance requirements and staffing standards, among other factors. In contrast to shipboard manpower requirements, which are determined using a model, each shore command establishes its own procedures and methodology to determine and validate manpower requirements due to the variations among the commands' missions and workload. These procedures and methodology are to be analytically proven, such as through industrial

[1]An activity is a unit, organization, or installation performing a specific mission or function and established under a commanding officer or officer in charge.

engineering studies, mathematical models, and better business practices, among others.[2] Major shore commands develop manpower requirements for peacetime and wartime scenarios separately, in which the workload and thus manpower requirements could vary. Major shore commands must review manpower requirements on a continuous basis to ensure they support the MFT, and should determine manpower requirements after major revisions to the MFT, new equipment changes, technology adjustments to workflow, or other changing conditions.[3]

After major shore commands determine and validate their manpower requirements, the positions are filled based on budget and resource allocation decisions. The major shore commands create a Program Objective Memorandum, which informs the service's, department's, and ultimately the President's budget submission, which is subject to congressional approval. Thus, changes to manpower requirements do not result in immediate changes to shore personnel manning and, furthermore, there may be a gap between the validated requirements and the shore personnel manning due to funding and personnel inventory as established by annual defense authorization and appropriation acts.

In January 2008, responding to a request from the Office of the Chief of Naval Operations (OPNAV), the Center for Naval Analyses identified challenges with the shore manpower determination process, including a lack of standardization among similar activities and issues with staff qualifications, among others, which echoed our previous findings in a 1997 report on Navy personnel.[4] According to Navy officials, OPNAV is chairing a project team to improve the process and deliver revised direction for making shore activity plans and establishing training for determining shore manpower requirements, due in fiscal year 2017. The project team also plans to encourage major shore commands to measure workload using standard methods of analysis for similar activities. In September 2016, Fleet Forces Command launched a pilot training program for analysts of other shore commands, intended to improve the consistency in how various major shore commands conduct their

[2]Office of the Chief of Naval Operations Instruction (OPNAVINST) 1000.16L, *Navy Total Force Manpower Policies and Procedures* (June 24, 2015) (change transmittal 1, Apr. 28, 2016).

[3]Ibid.

[4]GAO, *Force Structure: Streamlining Plans Could Enable Navy to Reduce Personnel Below Fiscal Year 1999 Goal*, GAO/NSIAD-97-90 (Washington, D.C.: Apr. 18, 1997).

manpower reviews. In addition, Fleet Forces Command is working with OPNAV to develop a model to predict changes in shore manpower needs.

Ford-Class Aircraft Carrier

(CVN 78)

Ship basics

CVN 78 ships are designed to replace *Nimitz*-class (CVN 68) aircraft carriers and operate with nearly 700 fewer crew members. Each ship in the new class is expected to save $3.7 billion in manpower costs and $2 billion in maintenance costs over its 50-year service life in comparison to *Nimitz*-class carriers.

Crew size

Goal: CVN 78 has manpower key performance parameters that reflect a reduction of 900 (objective) and 500 (threshold) positions compared to *Nimitz*-class carriers, which have a crew of 3,291 sailors.

Actual: CVN 78 crew size is currently 2,628, a reduction of 663 sailors below the *Nimitz* class, and within the threshold of 2,791.

Challenges

Four of CVN 78's 13 critical technologies remain immature, testing continues to reveal issues, and ship delivery has been delayed multiple times since 2014, with expected delivery in 2017.

In August 2016, DOD commissioned a review to determine where system dependencies pose risk to CVN 78 performance and to identify alternatives for mitigating those risks. The study concluded that it would be too disruptive to make any technological changes at this point, but noted the ongoing risk.

Technology and automation:

Technologies and ship design initiatives are expected to reduce watchstanding workload requirements and touch-labor required for some tasks (e.g., redesigned nuclear reactor plant is expected to result in a 50 percent manning reduction). Some of these technologies are detailed in table 4.

Table 4: CVN 78 Technologies, with Projected Manpower Reductions

Technology	Manpower reduction (in positions)
Advanced arresting gear	41
Advanced weapons elevator	Over 20
Dual band radar: multifunction radar and volume search radar	28
Electromagnetic aircraft launch system	32
Nuclear propulsion and electric plant	220 (includes reverse osmosis desalination system)

Source: GAO analysis of Navy information. | GAO-17-413

Shore support:

CVN 78's projected crew reductions do not depend on transferring maintenance or other work ashore. Program officials said that manpower reductions have been realized through the above technologies and design efficiencies or through changing work processes.

Crew size growth:

CVN 78 has not experienced crew size growth but has not yet entered active service. The preliminary manpower requirement set in 2011 and reestablished in 2017 called for 2,628 personnel, which is the current ship's force crew size.[1] Technology schedule delays (e.g., advance weapons elevators and dual band radar) have impacted the validation of preventive maintenance or watchstanding assumptions, or both, but are not believed by Navy officials to impact crew levels. Program officials noted that the crew size can grow by an additional 163 positions and still remain within the parameters. However, we have found that because of the lack of operational data on key systems, these ships will likely require additional personnel, and that the aircraft carrier can only accommodate a slight increase in personnel without requiring significant ship redesign.[2]

Operating and Support Costs:

The Department of Defense (DOD) estimates that it will cost an average of about $391 million to operate and support a CVN 78 ship per year, and calculates the average annual cost for *Nimitz*-class aircraft carriers to be about $490 million. There are not sufficient cost data available to determine CVN 78 operating and support savings because this ship is not yet in active service.

[1]The ship's force includes all personnel aboard the carrier except those designated as part of the air wing and in certain support or other assigned roles. An additional 1,912 personnel are expected to embark with the ship in addition to the ship's force.

[2]GAO, *Ford-Class Aircraft Carrier: Congress Should Consider Revising Cost Cap Legislation to Include All Construction Costs*, GAO-15-22 (Washington, D.C.: Nov. 20, 2014).

Zumwalt-Class Destroyer

(DDG 1000)

Ship basics

Compared to DDG 51 destroyers, which have an average crew size of 307 sailors, the DDG 1000 class is meant to require fewer crew members to carry out similar functions for watchstations, damage control, combat systems maintenance, and turbines.

Crew size

Goal: DDG 1000 has manpower key performance parameters for a crew of 125 (objective) and 175 (threshold).

Actual: The ship's current crew size is 175 (this includes a ship's force of 147 and an aviation detachment of 28).

Challenges

Six of DDG 1000's 11 critical technologies remain immature. The program reports that the ship's design is stable, but ongoing development and shipboard testing of technologies pose risk for design changes. DDG 1000 was delivered to the Navy in May 2016 and was commissioned in October 2016. The performance of DDG 1000's critical technologies and how they will be implemented in the fleet will not be known until all combat systems have been installed on the ship and it gains more operational experience.

Technology and automation:

The DDG 1000 has multiple new technologies designed in part to minimize manpower requirements, enhance efficiency, and reduce operating costs:

- multifunction radar that significantly reduces manning by enabling automatic operation with minimal human intervention,
- fire control systems that mitigate firefighting risks while enabling manpower reductions,
- a total ship computing environment that integrates all warfighting and peacetime applications into a single network and enables reduced numbers of watchstanders.

According to program officials, the ship's efficient interior layout has also made it possible to reduce crew size.

Shore support:

DDG 1000's shore-side support and maintenance are key elements that enable a significant reduction in crew when compared with previous destroyers, but shore-based maintenance will be accomplished through existing infrastructure such as regional maintenance centers and shipyards, while the training, logistics, and administrative assistance will be accomplished using military, civilian, and contractor personnel from the program office and class squadron.

Crew size growth:

The preliminary manpower requirement set in 2012 called for a crew of 158, and DDG 1000 has reached its crew size threshold of 175 personnel (crew size growth of 11 per cent). According to program officials, crew size increase was the result of lessons learned, and the crew approach was developed and updated as the ship design matured and ship construction progressed. Program officials suggested that crew size parameters should be reassessed and, if additional personnel are needed on the ship, there is space to accommodate them. Based on the Navy's ship delivery approach, DDG 1000 entered service in 2016 without any of its combat systems tested and sufficient time has not elapsed to evaluate the impact of the design and new technologies on manpower and costs. According to program officials, due to the crew's initial learning curve for new combat systems, ship commanders may require more crew in the short term.

Operating and Support Costs:

The Department of Defense estimates that it will cost an average of about $74 million to operate and support a DDG 1000 per year, and calculates the average annual cost for DDG 51 ships to be about $33 million, so there is not a cost savings expected. Since DDG 1000 has recently entered service, there are not sufficient actual cost data available to compare against the estimate.

Littoral Combat Ship (LCS)

Freedom (LCS 1) variant
Independence (LCS 2) variant

Ship basics

The LCS class consists of two different variants that are expected to replace frigates, mine countermeasures ships, and patrol coastal ships. Each ship is to undertake one of three missions: antisubmarine warfare, surface warfare, or mine countermeasures. The use of minimal manning was meant to lower operating and support costs over the ships' life cycle, compared to legacy frigates that had a crew size of 215.

Crew size

Goal: LCS has manpower key performance parameters for a core crew of 15 (objective) and 50 (threshold).

Actual: Recent changes to the LCS program have created an integrated core and mission crew of 70 sailors. Total number of ship crew including an aviation detachment and ensigns is 98.

Challenges

Sensors and other condition-based maintenance elements have functionality issues. Ship systems, including those in the propulsion plant that have recently experienced major casualties, indicate additional reliability issues. The Navy required LCS engineers to retrain following these major equipment failures, attributing some of them to human error. LCS personnel are concerned that these problems will continue with manning at current levels, even with the latest program changes.

Technology and automation:

The extensive use of automation and the overall design of the ship are meant to reduce manning on LCS. The class relies on a condition-based maintenance system wherein sensors and cameras remotely monitor equipment and spaces, reducing watchstanding requirements and thus crew sizes.

Shore Support:

Crew size reductions were also achieved by moving much of the maintenance traditionally executed by the ship's crew to shore-based contractors. Administrative, supply, and logistics tasks are also moved ashore, to be conducted by LCS Squadron staff. The number of squadron staff has increased along with the number of LCSs entering the fleet: from around 40 staff to support the first LCS in 2008 to about 470 total staff to support the seven LCSs delivered to the fleet by June 2016.

Crew size growth:

Total LCS crew size has grown from 75 in 2003 to 98 personnel in 2016, a 31 per cent increase that is detailed in table 5. Following a program review in 2016, LCS core and mission crews were integrated into a 70-sailor unit. There are 98 sailor berths within the ship; additional crew growth is not possible without redesigning interior spaces to accommodate more sailors.

Table 5: Growth in Littoral Combat Ship (LCS) Crew Size

Number of crew	2003	Changes through 2014	2016
Core crew	40	50	Integrated core and mission crew of 70
Mission crew (1 of 3):			
Antisubmarine (ASW)		ASW:15	
Surface warfare (SUW)		SUW: 19	
Mine countermeasure (MCM)	15	MCM: 20	
Aviation detachment	20	23	24
Ensigns[a]	0	3	4
Total	**75**	**91-96**	**98**

Source: GAO analysis of Navy information. | GAO-17-413.

[a]The Navy does not consider ensigns (junior officers) to be required by manpower analysis, but they nonetheless serve as functional members of every LCS crew due to their availability.

Operating and support costs:

The Department of Defense estimates that it will cost an average of about $55 million to operate and support an LCS per year. Although the Navy has described the LCS as a low-cost alternative to other surface ship classes, we found in 2014 that the available data indicate that the costs of the LCS may exceed or closely align with the costs of other multimission surface ships with larger crews.[1] According to Navy officials, the recent restructuring of LCS operational concepts demonstrates that reducing crew size does not generate the cost savings or cost avoidance that the Navy had anticipated.

[1]GAO, *Littoral Combat Ship: Deployment of USS Freedom Revealed Risks in Implementing Operational Concepts and Uncertain Costs*, GAO-14-447 (Washington, D.C.: July 8, 2014).

San Antonio–Class Amphibious Transport Dock

(LPD 17)

Ship basics

These ships are designed to transport Marines and their equipment and allow them to land using helicopters, landing craft, and amphibious vehicles. This class was designed to reduce crew sizes from earlier LPDs but does not rely upon new technologies, automation, or shore support as do newer ship classes.

Crew size

Goal: The LPD 17 program was tasked to reduce the manning for the 12 ships of its class by 25 percent of the total for the 41 ships it has replaced.

Actual: While there were about 14,000 crew members on antecedent ships, the LPD 17 class has a total crew size of less than 5,000, which falls within the 25 percent reduction target. There were no crew size target numbers or key performance parameters specified for LPD 17.

Challenges

During interviews with the LPD crews, officers and enlisted crew members we interviewed from two ships of this class told us that they did not believe the manpower requirement was sufficient for carrying out all required operations. The Navy last validated the LPD 17 manpower requirement in 2011, and officials told us they are tentatively scheduled to update it in fiscal years 2018 or 2019.

Technology and automation:

Some system integration and automation was installed on the ship in part to help reduce watchstanding workload and reduce crew sizes, including a shipboard-wide network that integrates combat, navigation, and other systems.

Shore support:

The ship class does not rely upon shore support for maintenance or other activities more than other amphibious ships, and not to the extent of newer platforms like the Littoral Combat Ship and DDG 1000.

Crew size growth:

The preliminary manpower requirement set in 2003 called for a crew of 363, and the ship's current manpower requirement is 378 personnel, a 4 percent increase. The average crew size of its antecedent ship class, LPD 4, was 364 sailors. Since the first ship of the class began construction in 2000, LPD 17 manpower requirements were adjusted through multiple iterations. The increase in the average crew size was driven by additional manning requirements related to system upgrades, and by manpower studies that identified and subsequently corrected other manning deficiencies. Crew members told us the ships do not have berthing spaces to accommodate additional Navy personnel without infringing upon designated spaces for Marines, who embark with the ship.

Operating and Support Costs:

Average annual LPD 17 operating and support costs are $42.8 million, compared to $36.4 million for its antecedent ship, LPD 4, an average annual per ship increase of $6.4 million.

GAO reported in 2016 that the Navy plans to build a replacement class of amphibious ships based on LPD design but with no new critical technologies. The Navy considers the LPD 17 design unaffordable and plans to remove some LPD 17 features on its replacement. The program office would not comment more about the planned replacement given its competition sensitivity.

Appendix VII: Shore Support Personnel

As the Navy reduced crew sizes aboard its ships as part of optimal manning and related initiatives beginning in 2001, it also reduced shore support positions in units responsible for maintenance and training. However, these positions have been mostly restored as of fiscal year 2015. From a peak in fiscal year 2006, the Navy reduced military personnel in units supporting surface ships by about 1,800 full-time equivalents (or about 24 percent) by fiscal year 2011. The Navy's Fleet Review Panel found that these reductions in shore support also contributed to degraded material condition of the surface fleet, and Navy officials told us they concluded that that the reductions in shore support contributed to declines in readiness during optimal manning. As of fiscal year 2015, the Navy has restored shore positions in units supporting surface ships to approximately their previous peak in fiscal year 2006.

Within shore support, however, there is variation in the extent to which positions have been restored. For example, positions in regional maintenance centers—which are responsible for conducting and overseeing intermediate-level maintenance on Navy ships—are about 19 percent above their prior peak in fiscal year 2006. Conversely, positions in training units that support surface ships and their crews remain about 13 percent below their prior peak in fiscal year 2006.

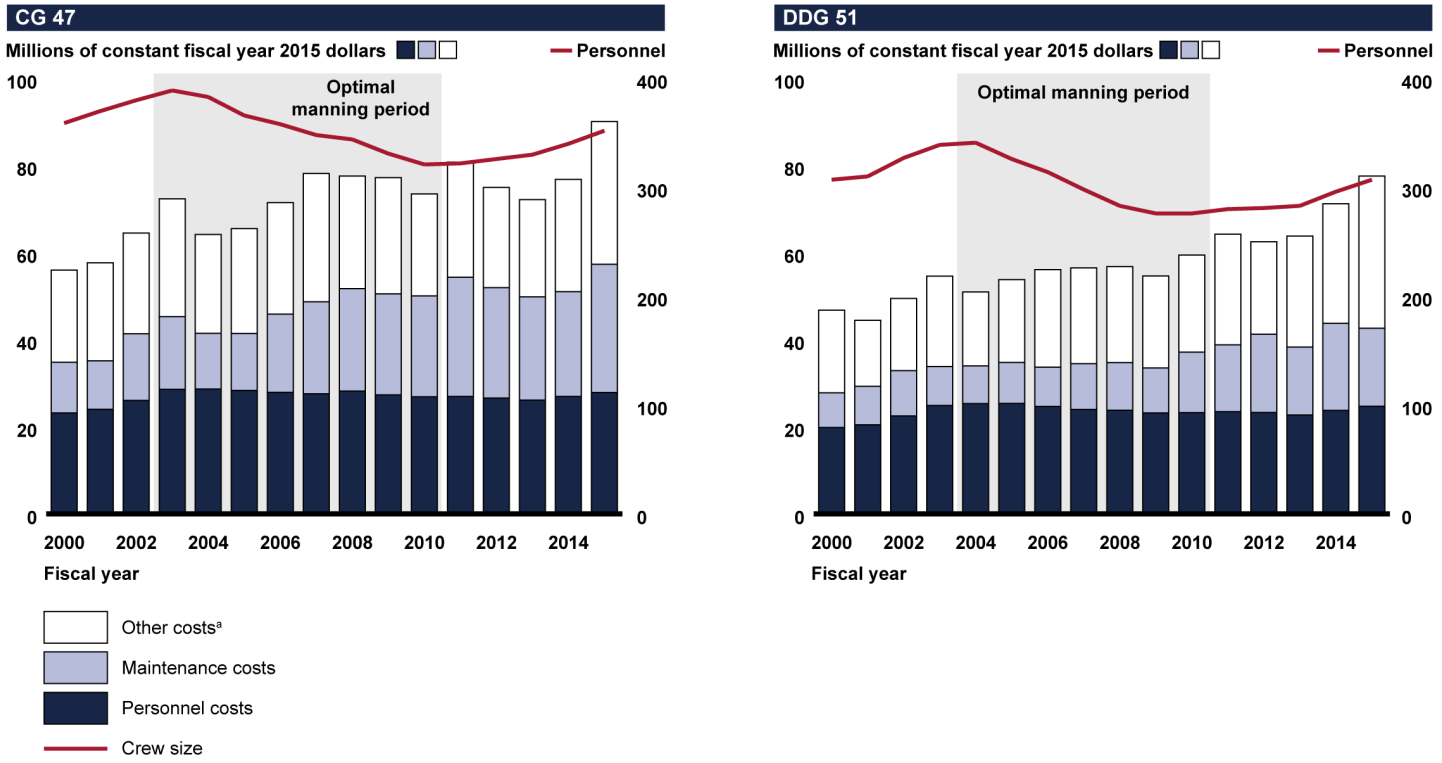
Appendix VIII: Average Operating and Support Costs and Crew Sizes by Ship Class

Our analysis found that overall operating and support costs increased for surface and amphibious ship classes during the optimal manning period and have continued to increase for most classes since the end of the optimal manning period.[1] This increase was driven in part by increases in maintenance costs offsetting decreases in personnel costs over this period. In technical comments on a draft of this report, Navy officials cited growth in entitlements and allowances as an additional contributing factor to increasing personnel costs over this period. Navy officials also noted that using different deployment models such as overseas homeporting and rotational crewing can also drive significant differences in operating and support costs even within a ship class, usually with the benefits of increased time on deployment. However, as we found in 2015, these approaches can also contribute to higher maintenance costs over the long term. Specifically, we found that ships homeported overseas incur higher operating and support costs than U.S.-homeported ships, and that some of these ships have had consistently deferred maintenance that resulted in long-term degraded material condition and increased maintenance costs.[2] Our 2015 analysis also showed that homeporting ships overseas provides additional time in a forward area of operations and additional deployed under way time compared to ships homeported in the United States, but that the additional time provided was primarily because training and maintenance periods are shorter than those provided for U.S.-homeported ships. Trends in ship operating and support costs for each ship class over this period are illustrated in figures 11 and 12.

[1]Operating and support costs include all costs reported in the Navy's Visibility and Management of Operating and Support Costs system. The costs reported include personnel, operations, maintenance, sustainment, and modernization for each ship. Personnel costs include the costs of all military, civilian and contractor manpower. Operations includes consumption of operating materials such as fuel, electricity, expendable stores, training munitions and other operating materials, unit-funded support activities, temporary additional duty/temporary duty associated with the unit's normal concept of operations, and unit-funded transportation services. Maintenance includes the cost of labor (outside of the scope of organizational-level) and materials at all levels of maintenance. Sustainment includes the cost of support services provided by centrally managed support activities, such as system-specific training and engineering support. Modernization includes the cost of hardware and software updates that occur after deployment of a system that improve a system's safety, reliability, maintainability, or performance characteristics to enable the system to meet its basic operational requirements throughout its life.

[2]GAO, *Navy Force Structure: Sustainable Plan and Comprehensive Assessment Needed to Mitigate Long-Term Risks to Ships Assigned to Overseas Homeports*, GAO-15-329 (Washington, D.C.: May 29, 2015).

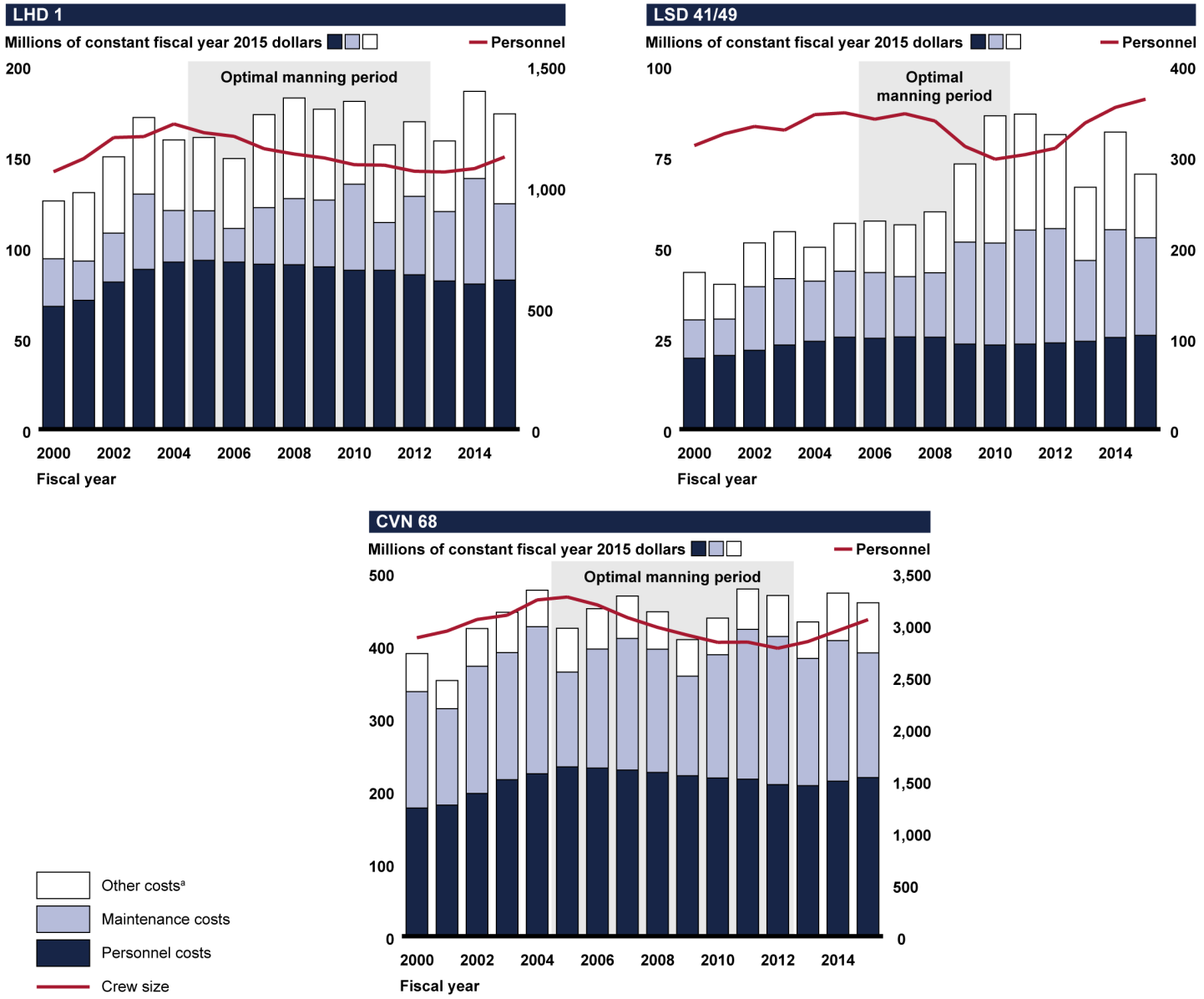
Figure 11: Average Operating and Support Costs and Crew Sizes by Ship Class for Cruisers (CG 47) and Destroyers (DDG 51), Fiscal Years 2000–2015



Source: GAO analysis of Navy data. | GAO-17-413

[a]Other costs" consists of operations, sustainment, and modernization costs.

Figure 12: Average Operating and Support Costs and Crew Sizes by Ship Class for Amphibious Assault Ships (LHD 1), Dock Landing Ships (LSD 41/49) and Aircraft Carriers (CVN 68), Fiscal Years 2000–2015



Source: GAO analysis of Navy data. | GAO-17-413

[a]"Other costs" consists of operations, sustainment, and modernization costs.

Appendix IX: Comments from the Department of Defense

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
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MANPOWER AND
RESERVE AFFAIRS

APR 28 2017

Mr. John Pendleton
Director, Defense Capabilities Management
U.S. Government Accountability Office
441 G Street, NW
Washington DC 20548

Dear Mr. Pendleton,

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO-17-413, 'NAVY FORCE STRUCTURE: Actions Needed to Ensure Proper Size and Composition of Ship Crews,' dated March 28, 2017 (GAO Code 100702). The Department appreciates the GAO's continued work in this area and is committed to ensuring the Navy's manpower requirements are current, analytically-based, and will meet the needs of the existing and future surface fleet. Accordingly, the Department of Defense concurs with all four recommendations made by the GAO.

RECOMMENDATION 1: GAO recommends that Under Secretary of Defense for Personnel and Readiness direct the Secretary of the Navy to have the Navy conduct a comprehensive reassessment of the Navy standard workweek and make any necessary adjustments.

RECOMMENDATION 2: GAO recommends that Under Secretary of Defense for Personnel and Readiness direct the Secretary of the Navy to have the Navy update guidance to require examination of in-port workload and identify the manpower necessary to execute in-port workload for all surface ship classes.

RECOMMENDATION 3: GAO recommends that Under Secretary of Defense for Personnel and Readiness direct the Secretary of the Navy to have the Navy develop criteria and update guidance for reassessing the factors used to calculate manpower requirements periodically or when conditions change.

RECOMMENDATION 4: GAO recommends that Under Secretary of Defense for Personnel and Readiness direct the Secretary of the Navy to have the Navy identify personnel needs and costs associated with the planned larger Navy fleet size, including consideration of the updated manpower factors and requirements.

We look forward to continuing to work with the GAO in this area. Should you have any questions, please contact my primary action officer for this engagement, Mr. Thomas Hessel at 703-697-3402 or thomas.j.hessel.civ@mail.mil.

Sincerely,

Rich Robbins
Director, Total Force Manpower & Resources

Appendix X: GAO Contact and Staff Acknowledgments

GAO Contact

John H. Pendleton, (202) 512-3489 or pendletonj@gao.gov

Staff Acknowledgments

In addition to the contact named above, Suzanne Wren, Assistant Director; Steven Banovac; Kerri Eisenbach; Bonnie Ho; Joanne Landesman; Amie Lesser; Shahrzad Nikoo; Daniel Ramsey; Michael Silver; John Van Schaik; and Chris Watson made key contributions to this report.